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*Technical Memorandum 33-426*

*Volume II*

# *Tracking and Data System Support for the Pioneer Project*

## *Pioneer VII. Prelaunch to End of Nominal Mission*

*N. A. Renzetti*



JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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## Preface

The work described in this report was performed by the Tracking and Data Acquisition organizations of the Jet Propulsion Laboratory, Air Force Eastern Test Range, and Manned Space Flight Network and by the NASA Communications Network of Goddard Space Flight Center. This volume covers the Tracking and Data System support for the *Pioneer VII* mission from the planning phase through the end of the nominal mission. Volumes I and III of this report present similar documentation relative to the *Pioneer VI* and *VIII* missions. Volume IV deals with *Pioneer IX* and with a subsequent planned but unsuccessful mission (*Pioneer E*).

## Acknowledgment

The author acknowledges the assistance of E. R. Allen, R. H. Grace, R. E. Purdue, A. J. Siegmeth, and J. W. Thatcher in compiling this report. The author also acknowledges the support, in the form of informal reports and material, of the operations staffs of the various networks, i.e., Air Force Eastern Test Range, Manned Space Flight Network, NASA Communications Network, and the Jet Propulsion Laboratory's Deep Space Network. The material relating to the launch vehicle and *Pioneer* spacecraft was abstracted from Ames Research Center and Goddard Space Flight Center reports.

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## Abstract

The *Pioneer VII* mission (outward trajectory, heliocentric orbit) employed six scientific instruments to accumulate information relative to interplanetary high-energy particles, solar phenomena, and plasma. The spacecraft also served as a celestial mechanics experiment reference point. The Tracking and Data System (comprising the Air Force Eastern Test Range, Deep Space Network, Manned Space Flight Network, and NASA Communications Network) tracked the spacecraft from launch through near-earth and deep space phases. For near-earth tracking, all Tracking and Data System facilities responded to mission, launch vehicle, and range requirements. For deep space tracking, the Deep Space Network responded to tracking, telemetry, command, monitoring, simulation, and operations control requirements.

N70-28131

# Tracking and Data System Support for the *Pioneer* Project

## *Pioneer VII*: Prelaunch to End of Nominal Mission

## I. Introduction

### A. General

The purpose of this document is to provide a history of the technical activities of the Air Force Eastern Test Range (AFETR), the Goddard Space Flight Center (GSFC), and the Deep Space Network (DSN) in support of the Ames Research Center (ARC) *Pioneer* Project. Included in this document are the Tracking and Data Acquisition (TDA) requirements, mission preparations of the participating agencies, a comprehensive account of tracking operations, and a Tracking and Data System (TDS) performance evaluation summary. A brief description of the TDS, the *Pioneer* spacecraft, the launch vehicle, and flight objectives is also provided to convey an understanding of TDS activities.

### B. Purpose

The primary purpose of the *Pioneer VII* mission was and is to accumulate scientific information. The time required for the analysis of such data is considerable. Furthermore, analyzing and reporting the results are the responsibilities of the individual scientific experimenters having instruments on the spacecraft. Some of the results have already been published; more will be published in future volumes documenting TDS activity.

*Pioneer VII* was the second spacecraft launched in this present series, and hence this report is the second description of the TDS activities in the *Pioneer* program. To aid in understanding the information presented, the spacecraft, the scientific instruments, and a portion of the related ground equipment are described herein. A listing is provided of major events and their time of occurrence during the *Pioneer VII* flight—from the preship review to the completion of the nominal mission phase when telemetry from the spacecraft could no longer be received by the 85-ft antennas. The test program and other activities are discussed in detail in Section IV. In addition, the discussion of the "preship" review includes information pertaining to the test program conducted on the spacecraft and scientific instruments.

The performance during the mission of various elements of the *Pioneer* Project is discussed in Section V.

Included is a description of the trajectory from launch and a discussion of the engineering performance of the spacecraft subsystems indicated by the telemetry data. The performance of the groups responsible for telemetry data retrieval and processing is also discussed. A TDS performance evaluation of the mission is summarized in Section VI.

*Pioneer VII*, the second spacecraft in the present series, was launched August 17, 1966. The *Pioneer VII* trajectory lies between 1.0 and 1.1 AU from the sun; after approximately 35 days from launch the spacecraft was following the earth in its orbit about the sun. In contrast, the *Pioneer VI* trajectory lies between 0.8 and 1.0 AU from the sun; after approximately 65 days from launch the spacecraft was leading the earth. In addition, because the difference in heliocentric celestial longitude between *Pioneers VI* and *VII* is approximately 135 deg at the date of this report and increasing, there is excellent azimuthal coverage of solar events. At the time of writing, all *Pioneer VII* equipment and scientific instruments were operating normally.

### C. Objectives

Scientific observations of the characteristics of magnetic fields, plasma, and high-energy particles in interplanetary space beyond the influence of the earth can provide a better understanding of the mechanism related to the propagation through space of solar disturbances, terrestrial phenomena related to such disturbances, and the relationship between solar and galactic fields. These characteristics are influenced by solar phenomena and vary both temporally and spatially. On a large time scale it is believed that they are influenced by the magnitude of solar disturbances, which vary periodically over an 11-yr cycle. Since such disturbances are generally localized on the sun's surface, and because the sun rotates, the spatial variation is surmised.

The objectives of the *Pioneer* Project are to conduct the aforementioned scientific observations and to determine the temporal and spatial variation of the interplanetary phenomena. To implement these objectives, the present plan calls for five flights, of which *Pioneer VI* was the first, to be launched at intervals of approximately eight to twelve months so as to cover the period from near-minimum solar activity to maximum solar activity. Spatial effects will be determined by launching two of these spacecraft in a direction so as to move ahead of the earth with increasing time and three of the spacecraft so as to move behind the earth with increasing time. *Pioneer VI* moves ahead of the earth; *Pioneer VII* moves behind it.

### D. *Pioneer* Program

The program began in the latter part of 1961 when a number of discussions between NASA Headquarters and ARC personnel about the scientific value and technical feasibility of the *Pioneer*-type missions culminated in the decision to have industry conduct a feasibility study of the mission. The study was concluded in April 1962 and became the basis of the technical information presented in a briefing to the NASA associate administrator in June 1962. The *Pioneer* Project was approved on November 9, 1962.

After a period of program planning and specification preparation, industry was solicited for proposals pertaining to the spacecraft and related equipment on January 29, 1963. The period of proposal evaluation, precontract discussions with industry, and explorations by NASA of the type of contract to be awarded ended in the selection of TRW Systems (known at the time of selection as Space Technology Laboratories, Inc., a subsidiary of Thompson Ramo Wooldridge, Inc.) as the contractor for the spacecraft and mission-dependent ground operation equipment. The selection date was June 7, 1963. A letter contract was signed on August 4, 1963, and the contract was definitized on July 30, 1964. The contract was "fixed-price incentive," the first such contract awarded by NASA for the development of a spacecraft.

Scientists were solicited for proposals for instruments to be flown on *Pioneers VI* and *VII* on February 1, 1963. The six scientific experiments were selected on July 23, 1963.

The period of studies and project definition, in which the planning and performance of activities prior to the start of the design phase were accomplished, ended with the first coordination meeting on August 26/27, 1963. The meeting was attended by all experimenters and by personnel from ARC and TRW Systems. Approximately 21 months had elapsed since the start of the program.

After the coordination meeting, the design of both the spacecraft and scientific instruments began. During this period, liaison and coordination with other groups who would provide launch and ground operation support was also initiated. The fabrication of spacecraft and instrument subsystems commenced during the second quarter

of 1964, and the integration and test activities at TRW started during February 1965. The design phase for *Pioneers VI* and *VII* ended with the preship review on September 29/30, 1965. This phase covered a period of 25 months.

The number of organizations contributing to the success of *Pioneers VI* and *VII* is probably several hundred or more, when account is taken of the many subcontractors supplying components and subsystems. To list all such organizations is beyond the scope or intent of this report. However, a number of organizations have played an important role in the program and will be mentioned frequently. Such organizations, together with their responsibilities and relations to other groups within the program, are described in Table 1.

*Pioneer VII* was the second spacecraft project to be managed by ARC. It was also the second spacecraft built under the direction of a facility other than JPL to be supported by the DSN, *Pioneer VI* being the first.

#### E. Tracking and Data System

The TDS provides the tracking and communications link between the space vehicle and committed earth-based stations. For *Pioneer* missions, the TDS uses the facilities of (1) AFETR, for tracking and telemetry of the spacecraft and vehicle during the launch and near-earth phases, (2) the DSN, for precision tracking commands, telemetry, communications, data transmission, processing, and computing, and (3) the Manned Space Flight Network (MSFN) and the National Aeronautics and Space Administration Communications System (NASCOM), both of which are operated by GSFC.

*1. Near-earth phase.* AFETR extends from the eastern United States mainland through the south Atlantic Ocean area eastward into the Indian Ocean. It includes all stations, sites, ocean areas and air space necessary to conduct missile and space vehicle test and development. Administrative and management activities are largely concentrated at Patrick AFB, while actual missile launches and flight tests are conducted at Cape Kennedy Air Force Station and over the downrange areas.

AFETR uses major instrumentation systems to support those projects, programs, and organizations that use AFETR launch facilities. As a part of the TDS, AFETR performs tracking and data acquisition functions for *Pioneer* missions during the countdown and launch phases of each flight. To meet the tracking and telemetry commitments for *Pioneer* missions, AFETR has at its disposal (1) land-based instrumentation sites, (2) range instrumentation ships (RIS), and (3) range telemetry aircraft.

The MSFN is under the direction of GSFC, located at Greenbelt, Maryland. The MSFN is part of a worldwide network designed for supporting the near-earth manned space flight effort. The MSFN has certain responsibilities for tracking and data acquisition, communications, and computer support placed upon it by the *Pioneer* Project. From the MSFN facilities, launch, first tracking, and launch mark event activities are monitored. By use of the switching communications and monitoring arrangements (SCAMA), voice operations and control are linked to all MSFN tracking stations committed to support *Pioneer* missions.

*2. Deep space phase.* The DSN, established by the NASA Office of Tracking and Data Acquisition, is under the system management and technical direction of JPL. The DSN is responsible for two-way communications with unmanned spacecraft traveling from approximately 10,000 mi from earth to interplanetary distances. Tracking and data-handling equipment to support these missions is provided. Present facilities permit simultaneous control of a newly launched spacecraft and a second one already in flight. In preparation for the increased number of U.S. activities in space, a capability is being developed for simultaneous control of either two newly launched spacecraft plus two in flight, or four spacecraft in flight. Advanced communications techniques are being implemented to make possible obtaining data from, and tracking spacecraft to, planets as far out in space as Jupiter.

The DSN is distinct from other NASA networks such as the Space Tracking and Data Acquisition Network, which tracks earth-orbiting scientific and communication satellites, and the MSFN, which tracks the manned spacecraft of the *Gemini* and *Apollo* programs. The DSN is composed of (1) the Deep Space Instrumentation Facility (DSIF), (2) the Space Flight Operations Facility (SFOF) and (3) the Ground Communications Facility (GCF).

The deep space tracking stations are situated such that three prime stations may be selected approximately 120 deg apart in longitude in order that a spacecraft in or near the ecliptic plane is always within the field of view of at least one of the selected ground antennas. Locations of Deep Space Stations are shown in Table 2.

Table 1. Principal elements of the *Pioneer* Project

| Organization | Responsibility |
|---|---|
| **Program** | |
| Lunar and Planetary Programs Office within Office of Space Sciences and Application (OSSA) | *Pioneer* Project direction at NASA Headquarters until shortly after *Pioneer VII* launch |
| Physics and Astronomy Program Office within OSSA | *Pioneer* Project direction at NASA Headquarters after transfer of responsibility from Lunar and Planetary Programs Offices |
| Ames Research Center | Project management |
| **Spacecraft, mission-dependent ground operational equipment** | |
| Ames Research Center | Spacecraft and ground operational equipment (GOE) systems management; GOE installation and checkout |
| TRW Systems | Design, development, and fabrication of spacecraft and GOE; integration and testing of spacecraft and instruments at TRW and Cape Kennedy Air Force Station |
| W. V. Sterling, Inc. | Assessment of spacecraft reliability and monitoring of quality assurance activities at TRW |
| **Scientific instruments** | |
| Ames Research Center | Instrument systems management |
| Fermi Institute, University of Chicago | Design, fabrication, and testing of cosmic ray detector; reduction, analysis, and reporting of data from instrument |
| Goddard Space Flight Center | Design, fabrication, and testing of magnetometer; reduction, analysis, and reporting of data from instrument |
| Massachusetts Institute of Technology | Design, fabrication, and testing of plasma detector; reduction, analysis and reporting of data from instrument |
| Graduate Research Center of the Southwest | Design, fabrication, and testing of cosmic ray detector; reduction, analysis and reporting of data from instrument |
| Stanford University, Stanford Research Institute | Design, fabrication, and testing of radio propagation detector; reduction, analysis, and reporting of data from instrument |
| Ames Research Center | Plasma detector subsystem management; reduction, analysis, and reporting of data from instrument |
| Marshall Laboratories | Design, fabrication, and testing of ARC plasma detector |
| **Launch vehicle** | |
| Goddard Space Flight Center | Management of launch vehicle procurement |
| Douglas Aircraft Company | Design and fabrication of *Thor* booster (first stage of *Delta* launch vehicle); integration and testing of *Delta* at Cape Kennedy Air Force Station |
| Douglas Aircraft Company | Design and fabrication of second stage of *Delta* |
| Alleghany Ballistics Laboratory | Design and fabrication of third stage of *Delta* |
| Thiokol | Design and fabrication of first-stage strap-on solid-propellant motors |
| **Launch activities** | |
| Unmanned Launch Operations, Kennedy Space Center | Direction of launch operations |
| Air Force Eastern Test Range | Tracking and telemetry data acquisition during powered flight |
| **Flight operations** | |
| Ames Research Center | Planning, direction, and control of mission |
| Jet Propulsion Laboratory | Management of DSN |
| Deep Space Network | Tracking, telemetry data acquisition, and command transmission during free-flight trajectory |
| NASA Communications Network | Communications between the various stations conducting flight operations |
| **Data processing and analysis** | |
| Ames Research Center | Management of preliminary data-reduction activities; dissemination of telemetry data to users; analyses of spacecraft and instrument engineering measurements |
| Computer Sciences Corporation | Design, development, and operation of telemetry-data tape processing station |
| Scientific Instruments (see Section I-H) | Reduction, analysis, and reporting of scientific data by individual experiments |
| TRW Systems | Support for analysis of spacecraft engineering measurements |

Table 2. Locations of Deep Space Stations

| Location | Deep Space Station (DSS) number | Geodetic latitude | Geodetic longitude | Height above mean sea level, m | Geocentric latitude | Geocentric longitude | Geocentric radius, km |
|---|---|---|---|---|---|---|---|
| Goldstone, Calif. (Pioneer) | DSS 11 | 35.38950°N | 243.15175°E | 1037.5 | 35.20805°N | 243.15080°E | 6372.0341 |
| Goldstone, Calif. (Echo) | DSS 12 | 35.29986°N | 243.19539°E | 989.5 | 35.11861°N | 243.19445°E | 6372.0176 |
| Goldstone, Calif. (Venus) | DSS 13 | 35.24772°N | 243.20599°E | 1213.5 | 35.06662°N | 243.20507°E | 6372.2599 |
| Goldstone, Calif. (Mars) | DSS 14 | 35.42528°N | 243.12222°E | 1160 | 35.24376°N | 243.12127°E | 6372.1341 |
| Woomera, Australia | DSS 41 | 31.38314°S | 136.88614°E | 144.8 | 31.21236°S | 136.88614°E | 6372.5317 |
| Tidbinbilla, Australia | DSS 42 | 35.40111°S | 148.98027°E | 654 | 35.21962°S | 148.98027°E | 6371.6686 |
| Johannesburg, S. Africa | DSS 51 | 25.88921°S | 27.68570°E | 1398.1 | 25.73876°S | 27.68558°E | 6375.5415 |
| Madrid, Spain, (Robledo) | DSS 61 | 40.429°N | 355.751°E | 800 | 40.238°N | 355.751°E | 6370.0868 |
| Cerebros, Spain | DSS 62 | — | — | — | — | — | — |
| Cape Kennedy, Fla. | DSS 71 | 28 48713°N | 279.42315°E | 4.0 | 28.32648°N | 279.42315°E | 6373.2913 |
| Ascension Island | DSS 72 | 7.95474°S | 345.67242°E | 526.7 | 7.89991°S | 345.67362°E | 6378.2386 |

The acquisition of a spacecraft signal may involve six different functions: (1) pointing the antenna at the spacecraft, (2) tuning and locking receivers to the spacecraft transmitted frequency, (3) tuning and locking the ground transmitter to the spacecraft receiver frequency, (4) establishing range lock, where applicable, (5) synchronizing the telemetry system, and (6) in some cases providing for immediate command transmission to the spacecraft. Selected stations are equipped with acquisition aid antennas mounted on the 85-ft antennas to assist in the acquisition process. The acquisition aids have beamwidths of approximately 16 deg and are accurately boresighted with the 85-ft antennas. They have angle-error outputs which are connected to a separate angle channel receiver. By observing the angle errors generated simultaneously by both wide- and narrow-beamwidth antennas, a smooth change from tracking with the acquisition aid to tracking with the 85-ft antenna can be effected. Thus tracking, telemetry, and control of the spacecraft are properly attained.

The SFOF is located at the Jet Propulsion Laboratory in Pasadena, California. Before launch, direction and status monitoring of the DSN, analysis of spacecraft and scientific instrument performance, and calculation of predictions for spacecraft acquisition by the DSN are performed there. Within minutes after launch, mission control is transferred to this facility and tasks associated with this responsibility are performed in addition to the above. Within several weeks after the *Pioneer VII* launch, mission control and the spacecraft and scientific performance analysis teams were transferred to ARC.

In the strict sense, there was no mission-dependent equipment at either the SFOF or ARC mission operation areas. The arrangement of the equipment was, however, peculiar to *Pioneer*. Therefore, the description of these areas at the SFOF and ARC will be deferred.

The DSN, managed by JPL, provided all tracking, data acquisition, and command capability for the free-flight phase of *Pioneer VII*. The stations within the network which have supported *Pioneer VII* are DSS 11, 12, 14, 41, 42, 51 and 61.

Principal support during the early phase of the *Pioneer VI* mission was provided by Stations 12, 42, and 51, since they were the only tracking stations with the

necessary mission-dependent ground operational equipment (GOE). (DSS 71 was also supplied with GOE. This station is used only for prelaunch checkout and did not track the spacecraft during the early phase.) A microwave system connecting DSS 12 with DSS 11 and DSS 14 provides the capability for utilizing the GOE at DSS 12 in combination with the mission-independent equipment at DSS 11 and DSS 14.

With the exception of DSS 14, which has a 210-ft-diam antenna (Fig. 1), all the participating stations are equipped with 85-ft-diam antennas. The antennas are parabolic reflectors that operate without radomes and, except for DSS 14, use polar mounts at S-band frequencies. A Cassegrain feed system is used and the low noise preamplifier is mounted in the Cassegrain cone assembly. Table 3 gives the characteristics for S-band tracking systems such as these. The gain of the 85-ft antennas is approximately 53 dB when receiving and 51 dB when transmitting. The beamwidth is 0.35 deg. Acquisition aid antennas are also mounted on the reflectors at DSS 41, 42, and 51. These waveguide horn antennas have a gain of approximately 21 dB when receiving and 20 dB when transmitting and a beamwidth of 16 deg. This large width eases the problems associated with initial acquisition of the spacecraft following launch; the problems are caused by inaccuracies in the predictions resulting from the lack of tracking or precise attitude control of the third stage, or by delays in receiving predictions based on first- and second-stage tracking.

The Goldstone Mars station (DSS 14) is equipped with a 210-ft-diam antenna which is a parabolic reflector, but one that uses an azimuth–elevation mount. The gain is

**Table 3. Characteristics for S-band tracking systems**

| | | | |
|---|---|---|---|
| Antenna, tracking | | Transmitter | |
| Type | 85-ft parabolic | Frequency (nominal) | 2113 Hz |
| Mount | Polar (HA-Dec) | Frequency channel | 14b |
| Beamwidth ±3 dB | ~0 4 deg | Power | 10 kW, max |
| Gain, receiving | 53.0 dB, +1.0, −0.5 | Tuning range | ±100 kHz |
| Gain, transmitting | 51.0 dB, +1.0, −0.5 | Modulator | |
| Feed | Cassegrain | Phase input impedance | ≥ 50 Ω |
| Polarization | RH circular | Input voltage | ≤ 2.5 V peak |
| Max. angle tracking rate[a] | 51 deg/min = 0.85 deg/s | Frequency response (3 dB) | DC to 100 kHz |
| Max. angular acceleration | 5 0 deg/s/s | Sensitivity at carrier output frequency | 1.0 rad peak/V peak |
| Tracking accuracy ($1\sigma$) | 0.14 deg | Peak deviation | 2.5 rad peak |
| Antenna, acquisition | | Modulation deviation stability | ±5% |
| Type | 2 × 2-ft horn | Frequency, standard | Rubidium |
| Gain, receiving | 21.0 dB ±1.0 | Stability, short-term ($1\sigma$) | $1 \times 10^{-11}$ |
| Gain, transmitting | 20.0 dB ±2.0 | Stability, long-term ($1\sigma$) | $5 \times 10^{-11}$ |
| Beamwidth ±3 dB | ~16 deg | Doppler accuracy at $F_{rc}$ ($1\sigma$) | 0.2 Hz = 0.03 m/sec |
| Polarization | RH circular | Data transmission | Teletype and high-speed data lines |
| Receiver | S-band | | |
| Typical system temperature<br>With paramp<br>With maser | <br>270 ±50°K<br>55 ±10°K | | |
| Loop noise bandwidth threshold ($2B_{LO}$) | 12, 48, or 152 Hz +0, −10% | | |
| Strong signal ($2B_{LO}$) | 120, 255, or 550 Hz +0, −10% | | |
| Frequency (nominal) | 2295 Hz | | |
| Frequency channel | 14a | | |

[a]Both axes.

Fig. 1. Goldstone Mars Deep Space Station (DSS 14), with 210-ft antenna

approximately 62 dB when receiving and 60 dB when transmitting. The beamwidth is 0.1 deg. The antenna was dedicated on April 29, 1966, and therefore was used extensively *Pioneer VII* during this reporting period.

The Deep Space Station transmitters operate between approximately 0.2 and 10 kW. The maximum power is sufficient to transmit to the spacecraft whenever reception from the spacecraft is possible. The lower power can be used when the spacecraft is near the earth.

The Deep Space Stations are equipped with a parametric amplifier and a helium-cooled traveling wave maser. At 2295 MHz, the system noise temperature of the former is 270 $\pm 50^{\circ}$K and that of the latter between 35 and 50°K.

All Deep Space Station receivers are of the phase-lock-loop type and operate at S-band. These receivers lock to the carrier, detect the subcarrier signal and supply the signal to the mission-dependent equipment for demodulation and further processing. Each Deep Space Station is also equipped with two FR-1400 tape recorders and two SDS-910 or 920 computers for use by the flight projects. The former record telemetry data directly from the receivers and from the mission-dependent equipment and other information from instruments at the ground station. The latter are used in the *Pioneer* system to perform many functions associated with telemetry and command such as:

(1) Monitoring spacecraft telemetry data and generating alarms for out-of-tolerance performance.

(2) Selective editing of telemetry data and preparation for teletype transmission of data to the mission operation areas.

(3) Verifying commands transmitted to the spacecraft and determining that these commands have been executed.

### F. *Pioneer Spacecraft*

*Pioneer* spacecraft carry six scientific instruments to investigate the characteristics of magnetic fields, plasma, and cosmic rays in interplanetary space. *Pioneer VII* was launched from Cape Kennedy Air Force Station on August 17, 1966. At the time of this writing, all scientific instruments and spacecraft equipment have continued to operate normally. There have been no malfunctions or anomalous performances which have affected the objectives of the mission. In addition, a mass of information presenting the measurements made by the scientific instruments and the performance of the spacecraft subsystems have been telemetered from the spacecraft and received on the ground since the launch. A number of organizations performing a variety of tasks have contributed to this success. This report describes a number of these tasks and discusses the performance of the spacecraft and the TDS.

During the first seven months of the mission, the spacecraft was tracked by the DSN 85-ft-diam antennas. Tracking during this early flight phase of the mission was nearly two-thirds of full time. Subsequently, the spacecraft was tracked by the single DSN 210-ft-diam antenna because of the great distance between the earth and the spacecraft. During this part of the mission, the tracking was relatively sparse; in addition, no unique tasks were performed, and the performance of the spacecraft and instruments was essentially the same as that during the cruise phase. Therefore, the information presented herein covers only the first seven months of the *Pioneer VII* mission.

The *Pioneer* spacecraft was specially designed and fabricated to provide the means for exploring interplanetary particle and field phenomena at great distances from earth and to meet the constraints imposed by interfacing systems. The general requirements were the following:

(1) Provide a stable platform on which to mount scientific instruments to measure interplanetary phenomena at distances up to 75 million km from earth.

(2) Provide a capability for the instruments to scan 360 deg in the plane of the ecliptic.

(3) Provide a magnetically clean spacecraft with a field strength of less than 1 $\gamma$ at the magnetometer.

(4) Operate in space for at least 6 mo.

(5) Weigh less than 150 lb (including scientific instruments).

(6) Provide a thermal environment favorable to the operation of on-board equipment.

(7) Provide a data system to sample readings from the instrumentation and transmit the information to earth.

(8) Provide a command system to permit changes in operating modes of on-board equipment by ground command.

The weight limitation and the requirements for flight in interplanetary space are compatible with the performance of the *Delta* launch vehicle. The spacecraft size and overall profile are also compatible with the fairing of the launch vehicle. Lastly, the structure meets the strength and rigidity requirements to withstand the vibration and acceleration loads of the launch vehicle.

The telemetry and command communication subsystems are compatible with the requirements of the DSN and the need for communication at large distances. The communication subsystem operates at S-band frequencies. When the subsystem operates in a "coherent" mode, the frequency transmitted from the spacecraft is a fixed ratio of that received by the spacecraft; as a result, accurate doppler measurements can be made so that the spacecraft velocity relative to earth and, hence, the trajectory can be determined. The telemetry communication subsystem also operates at a frequency governed by an on-board oscillator to provide for occasions when the ground stations are not transmitting to the spacecraft or when doppler measurements are not required.

The spacecraft is spin-stabilized. Thus the stability requirements can be met within the overall weight and lifetime constraints, since the necessity for attitude correction is minimized and the on-board orientation subsystem is small, lightweight, and reliable. Alignment of the spin axis perpendicular to the plane of the ecliptic for the major portion of the mission provides the required scan capabilities.

The spacecraft is cylindrical and has three radial booms, an antenna mast on the cylinder axis at the forward end of the spacecraft, and an antenna system at the aft end of the spacecraft for use in one of the scientific experiments (Stanford). Except for a small viewing band provided for the scientific instruments, the curved surface of the cylinder is covered with solar cells to supply the on-board power. Within the cylinder is a single platform on which all the electronic equipment for the spacecraft and scientific instruments is located. Thermal louvers aft of the equipment platform cover a portion of the platform area and control the amount of heat radiated from that surface. These various components are shown in Fig. 2.

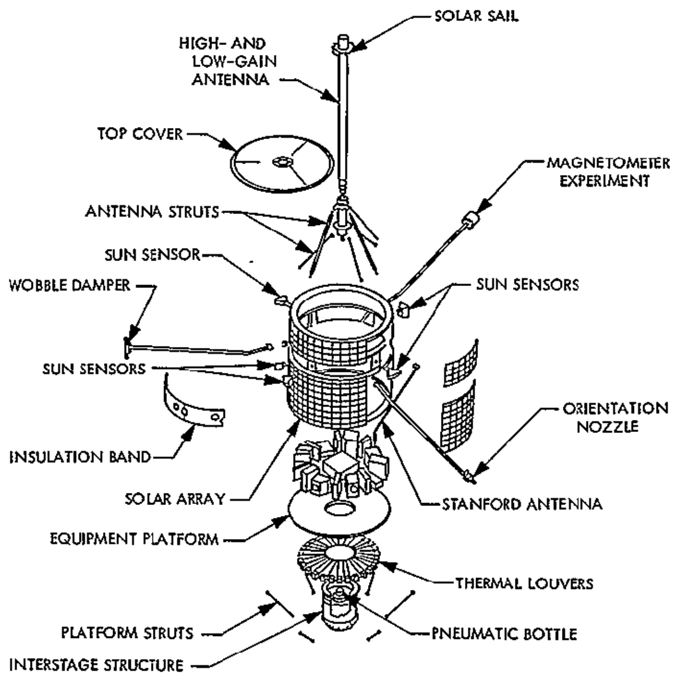


**Fig. 2. Exploded view of the *Pioneer VII* spacecraft**

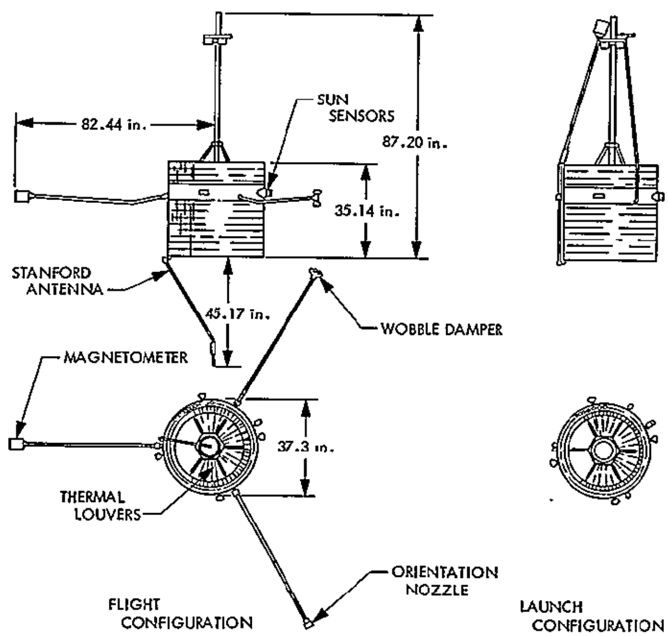


**Fig. 3. *Pioneer VII* spacecraft configuration**

The booms can be folded against the antenna mast and the Stanford antenna against the cylinder (Fig. 3) so that the spacecraft can fit within the launch vehicle fairing. After separation from the third stage, the booms and Stanford antenna are automatically deployed. The three booms augment the spacecraft moment of inertia

about the spin axis to achieve the gyroscopic stabilization required for the mission. In addition, the magnetometer is at the end of one of the booms so as to be as far as possible from spacecraft equipment which induces magnetic fields. One boom has a nozzle which, as part of the nitrogen gas jet system, provides the torque for attitude control of the spacecraft; the third boom has a wobble damper at its end.

To provide the required communication capabilities within the constraints imposed by the electrical power subsystem, the antenna mast is a high-gain antenna having a disk-like pattern which is axially symmetric with respect to and perpendicular to the spin axis. Since the spin axis is perpendicular to the ecliptic plane and since the earth and spacecraft are in the ecliptic plane, such a pattern assures that the earth will be illuminated by radiation from the spacecraft without a separate antenna pointing system.

The magnetic-cleanliness requirement is eased somewhat by placing the magnetometer sensor at the end of the boom rather than on the equipment platform. Nevertheless, careful selection of materials and components throughout the spacecraft and use of magnetic compensation design techniques were necessary to fully achieve this requirement.

### G. Launch Vehicle

The launch vehicle for the *Pioneer VII* was the thrust-augmented improved *Delta* (DSV-3E). The prime contractor for the vehicle is Douglas Aircraft Company. The vehicle had basically three stages, but in addition had three solid-propellant motors augmenting the first-stage thrust. These components and their principal dimensions are shown in Fig. 4. This launch was the first in which the *Delta* placed the payload in an escape-from-earth trajectory.

The first stage was a modified *Thor* powered by a Rocketdyne MB-3 block III engine and augmented by three Thiokol solid-propellant rockets. The liftoff weight was approximately 150,000 lb; the liftoff thrust was 325,000 lb, of which 175,600 lb was supplied by the first stage. The fuel was RP-1 kerosene; liquid oxygen was the oxidizer. The main engine burned for approximately 148 s. The three Thiokol solid-propellant rockets were started at the time of main engine start and burned for approximately 40 s. Approximately 70 s after burnout, the solid-rocket cases were ejected. During the first-stage burn, the pitch and yaw control was effected by gimballing the main engine in response to signals from an inertial reference package which also maintained roll control by positioning the gimballed vernier engines. A radio guidance system in the second stage also provided first-stage corrective steering signals.

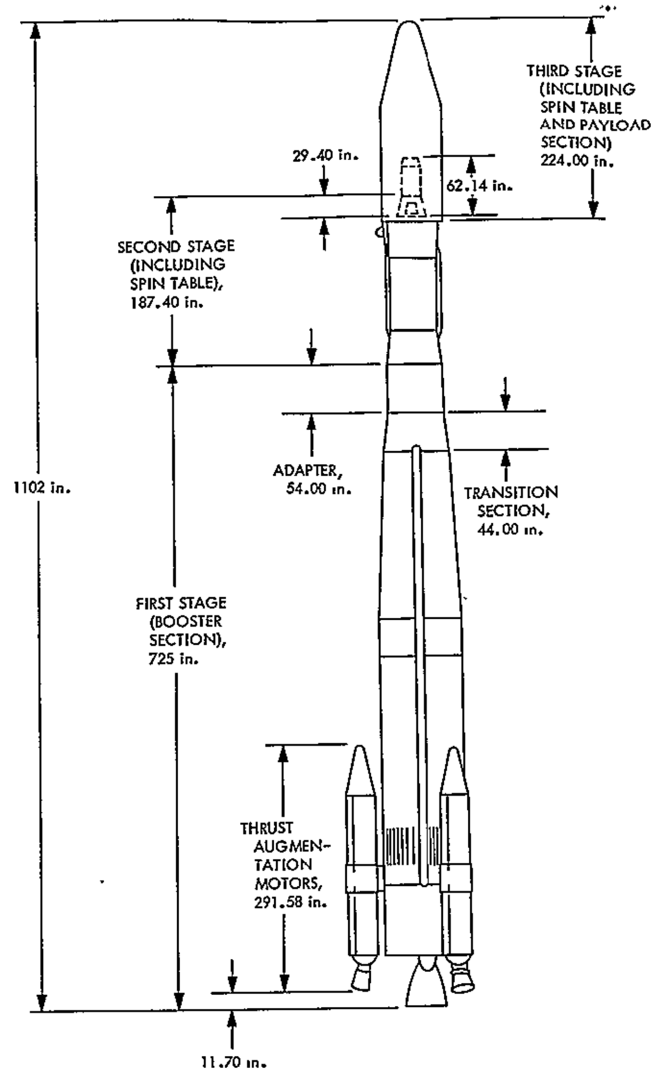


**Fig. 4. Thrust-augmented improved *Delta* launch vehicle**

Second-stage thrust was supplied by a pressure-fed Aerojet General Corporation AJ10-118E liquid-propellant propulsion system. The weight at ignition was approximately 14,000 lb, and the thrust was about 7,400 lb. The fuel was unsymmetrical dimethylhydrazine, and the oxidizer was inhibited red fuming nitric acid. The motor burned approximately 6½ min. During the power portion of the second-stage flight, the main engine was gimballed to control pitch and yaw. Roll was controlled by four on-off type cold gas jets, two reacting in a clockwise direction and two in a counterclockwise direction.

Both pitch and yaw control systems responded to commands from the second-stage programmer as well as from the radio guidance system and inertial reference package. A velocity cutoff system was also incorporated in the second-stage guidance compartment.

The launch vehicle could delay third-stage ignition until 1800 s after second-stage cutoff. During this coasting phase, an on-off type nitrogen gas jet used four solenoid-operated jets radially mounted on the aft end of the second stage for pitch and yaw control plus the four gas jets used during second-stage powered flight for roll control. The nitrogen gas used was that previously used to pressurize the fuel tanks.

The third-stage propulsion for *Pioneer VII* was the ABL X-258 rocket motor. The weight at ignition was about 735 lb, including the spacecraft; the thrust was about 6,200 lb. Attitude control for the third stage was maintained by spin-stabilizing the third stage and spacecraft combination prior to separation from the second stage. The size of the third stage relative to the spacecraft was also considerable. The spacecraft was mounted on an X-258 motor; the spin-up table and third-stage attach fixture were also configured. This assembly was used for checking the handling procedures for the spacecraft and third stage prior to mating the *Pioneer VII* spacecraft, X-258 motor, and second stage. The aerodynamic fairing for the third-stage/spacecraft combination was the standard improved *Delta* fairing.

Data needed to assess the performance of the launch vehicle was telemetered from the first and second stages. The first-stage telemetry was at a frequency of approximately 230 MHz. Modulation was PDM/FM/FM (pulse duration modulation/frequency-modulated/frequency-modulated). The second-stage telemetry was also at a frequency of approximately 230 MHz. Modulation was PDM/FM/FM. No telemetry data was received from the third stage. The second stage was also provided with a C-band radar transponder system of 500 W peak power.

### H. Scientific Experiments

Six scientific instruments comprise the scientific payload for *Pioneer VII*: two cosmic ray detectors, two plasma detectors, a magnetometer, and a radio propagation instrument. A celestial mechanics experiment requires no special instruments on the spacecraft. The payload weighs 34.1 lb, approximately 25% of the total *Pioneer VII* weight. Nine W of power are required for the instruments when one plasma detector is operating in its low-power mode and 18 W when in the high-power mode, approximately 18 and 35% of the total *Pioneer VII* power.

The payload covers approximately 280 in.$^2$ of platform. Approximately 72% of the telemetry data is allocated directly to the scientific payload when telemetering in the scientific data mode. Except on rare occasions, this mode has been used throughout the mission. Approximately 33% of the command capability is allocated directly to the payload for controlling the operating conditions of the instruments.

Power to the scientific instruments is supplied directly from the spacecraft primary bus; each instrument, therefore, has its own converter. Power to all instruments can be turned off by a single ground command; each instrument can be turned on individually by ground command.

The scientific instruments have met the weight and structural integrity constraints imposed by the launch vehicle performance, acceleration, and vibration. They have also met stringent requirements for magnetic cleanliness. As with the spacecraft, materials and components were selected carefully, and the use of magnetic minimization or compensation design techniques was necessary. The requirement for long lifetime was also met by the careful selection of parts and by parts screening.

A brief description of the experiments and the related instruments is given below to indicate the type of scientific information being gathered by *Pioneer VII*. As stated previously, the reporting of the scientific results is the responsibility of the individual experimenters and is beyond the scope of this report except where mentioned for the sake of clarity.

*1. Cosmic ray detector (University of Chicago).* This instrument measures the intensity and energy spectrum of protons and alpha particles. In addition, it measures electron energy over a limited range, as well as particle anisotropy. The measurement of proton and alpha particle energy spectrum is divided into the following energy windows: 0.6 to 13, 13 to 70, 70 to 190, and greater than 190 MeV per nucleon. Detection of electron energy spectra is limited to the energy windows of 0.16 to 1 and 1 to 20 MeV.

The instrument has three solid-state lithium drifted detectors, a plastic scintillator cylinder designed to exclude particles not confined to the telescope cone angle of 60 deg, a photomultiplier tube, and associated electronics. Aside from the input discriminator logic, typical of this type of instrument, the electronics basically consists of the necessary readout logic to interface with the spacecraft data-handling subsystem, four counter registers which provide the nondestructive readout of four separate counting rates, one 128-channel pulse-height analyzer, one 32-channel pulse-height analyzer, and a solar aspect counter. The latter, using spacecraft timing signals, generates timing signals within the instrument to indicate the direction of the instrument axis relative to the sun so as to be able to determine the direction of the incoming particles. The first signal occurs and the cycle commences at the time that sun sensor E is illuminated by the sun; the instrument axis points 115 deg of spacecraft rotation ahead of the sun. The first internally generated signal occurs between 1/16 and 1/8 s later. Succeeding signals are 1/8 s apart until the spacecraft completes the revolution and the cycle starts again. The interval between the last signal and the start of the next cycle is generally less than 1/8 s because of the tolerance in the time of the first signal and because the spacecraft spin rate is not precisely a multiple of 1/8 s.

The instrument can operate in one of two modes, normal and calibrate. The mode of operation is selected by ground command. In the calibrate mode, the coincidence/anti-coincidence logic circuitry is disabled to permit individual counting rates of the three solid-state detectors to be read directly.

*2. Cosmic ray detector (Graduate Research Center of the Southwest).* This instrument measures the anisotropy of low-energy primary and solar cosmic radiation and measures its variation with energy, time, and nuclear species. The cosmic ray counting rates from four orthogonal directions in the plane of the ecliptic are recorded for energy windows of 7.5 to 45, 45 to 90, and 150 to 350 MeV per nucleon. The latter window records alpha particles or heavy nuclei alone. The lowest energy window, 7.5 to 45 MeV per nucleon, while intended to record protons or heavier nuclei, will also detect electrons in the energy range of 7.5 to 13 MeV. There is also an omnidirectional counting rate which records all particles of energy greater than 7.5 MeV per nucleon.

The instrument consists of a scintillator crystal, an anticoincidence scintillator, two photomultiplier tubes, and associated electronics. The acceptance cone for the detector is 107 deg. Energy window discrimination is achieved by means of a four-channel, on-board, pulse-height analyzer.

A time division circuit, the aspect clock, generates four time gates of precisely equal length. The first time period commences when the detector axis points 139 deg west of the sun. Succeeding periods commence at precisely 90, 180, and 270 deg of spacecraft rotation. Three primary modes of operation, *dynamic range off, dynamic range on,* and *calibrate* are selectable by ground command. In the *dynamic range off* operating mode, the length of each time period is equivalent to nearly 1/4 of a spacecraft revolution. In the *dynamic range on* operating mode, the length of each time period is equivalent to approximately 1/32 of a spacecraft revolution. These time gates route the pulses from any one channel of the pulse-height analyzer into one of four binary accumulators corresponding to each of the four time gates. Hence, concurrent measurements of cosmic ray fluxes are obtained from each of the three energy bands enumerated above.

The first operating mode described above is used during periods of relatively quiet solar activity, and the second is used during periods of extensive solar activity. The *calibrate* mode provides an in-flight check of pulse-height analyzer threshold utilizing a built-in americium 241 source, the accuracy of the time division of the aspect clock, and the overall integrity of the binary accumulators.

*3. Plasma detector (Massachusetts Institute of Technology).* This instrument measures the energy spectrum, flux, and angular distribution of both positive ions and electrons of the interplanetary plasma. The energy per unit charge of the positive ions is determined in 14 intervals extending from 0.1 to 9.5 kV. The energy of the electrons is determined in four energy bands extending from 0.1 to 1.6 keV. The flux sensitivity range is from $2 \times 10^5$ to $2 \times 10^9$ particles/cm$^2$/s.

The instrument consists of a detector that utilizes a Faraday cup with an energy-determining grid, a split collector, and associated electronics. A voltage applied to the grid alternates at approximately 1800 Hz between two voltage levels, thus producing a pulsating current at the collector by passing and then repelling incoming particles whose energy to charge ratio is within the applied voltage band. The electronics system is coupled to the collector and responds only to the pulsating component

of the current. The current from half of the split collector and the total collector current are measured; the ratio of these currents gives an approximate indication of the direction of flow in the plane of the spin axis. Measurements to be telemetered are stored as 6-bit words in a 256-word memory. The viewing angle is ±20 deg in the plane perpendicular to the spacecraft spin axis and ±60 deg in the plane parallel to the spin axis.

The data recording sequence consists of 16 revolutions of the spacecraft in which no data is recorded, alternating with 16 revolutions in which the 14 ion energy per unit charge bands, a single electron energy band, and a calibrate scan are covered. No data from the instrument is telemetered during this time. Thereafter, the data is telemetered until the memory is empty, at which time the recording sequence again commences but covers a different electron energy band. The angular distribution information is obtained by measuring the total particle flux in 28 consecutive intervals, each corresponding to 11¼ deg of spacecraft rotation. The first interval begins when the instrument axis is pointing 45 deg east of the sun, and the last interval ends when the instrument axis has rotated westward 270 deg beyond the sun. Data is recorded in each of the first 8 intervals (covering ±45 deg from the sun). In the remaining 20 intervals, only the maximum reading in each consecutive group of 4 intervals is recorded. In addition, the peak value of the flux striking half the collector in each revolution of the spacecraft, together with the interval number in which it occurred, is also recorded.

The instrument can be placed in one of two operating modes by ground command. In the primary mode, the instrument cycles through all the voltage intervals available. In the other mode, the four highest-voltage intervals are excluded.

*4. Plasma detector (Ames Research Center).* This instrument measures the energy spectrum, flux, and angular distribution of both positive ions and electrons of the interplanetary plasma. The energy per unit charge of the positive ions is determined in 16 logarithmically spaced bands extending from 0.2 to 10 kV. The energy of the electrons is determined in 8 logarithmically spaced bands extending from 0.002 to 0.5 keV. The flux sensitivity range is from $10^5$ to $10^9$ particles/cm$^2$/s. The instantaneous viewing angle is approximately 15 deg in the plane perpendicular to the spacecraft spin axis (equatorial plane) and ±80 deg in the plane parallel to the spin axis. The latter is divided into 8 channels which are symmetrical about the equatorial plane and have widths, commencing at the equatorial plane of 15, 15, 20, and 30 deg.

The instrument has a quadrispherical electrostatic analyzer, eight separate and contiguous current collectors to provide the eight sectors discussed above, and associated electronics. The current or flux measurement is expressed as a 7-bit word, and together with other information identifying energy levels, positive or negative particles, collector, and equatorial interval, is stored in a core memory. The instrument can record data concurrently with telemetering data.

The angular distribution about the spin axis is obtained by measuring the total particle flux in 15 consecutive intervals; the first four and last three correspond to 45 deg of spacecraft rotation, and the remaining eight correspond to 5⅝ deg of spacecraft rotation. The first interval begins at 202½ deg of spacecraft rotation before the instrument axis points toward the sun; thus the eight small intervals are symmetric with respect to the time of instrument axis and sun alignment.

The instrument is capable of four different data recording sequences. When the spacecraft is transmitting at 512 bits/s, the particle flux or current at a given energy per unit charge interval and for a single collector, together with associated identification information, is recorded for each of the 15 intervals during one revolution and for the interval and collector having the maximum flux during the second revolution. Twenty-four such pairs comprise the full energy cycle; eight such cycles, one for each of the eight collectors, comprise the full instrument cycle. When the spacecraft is transmitting at 256 bits/s, the volume of data is compressed by recording of data taken only during the eight short intervals corresponding to 45 deg of spacecraft rotation symmetric with the sun direction (first short-scan mode) or, in addition, that taken during the first seven of the eight short intervals (second short-scan mode). The mode can be selected by ground command. When the spacecraft is transmitting at 64 bits/s and lower, the volume of data is further compressed by acquiring data during the interval and for the one collector which observed the maximum flux during a single rotation of the spacecraft. In this mode, the ion and electron data are separately acquired and stored prior to being telemetered. In addition to the above, a ground-selectable *calibrate* mode is possible wherein a known voltage offset is provided which results in a simulated flux reading of approximately

64 counts (half-scale). This reading will continue to appear in the flux word position while the instrument remains in *calibrate*. The *calibrate* mode is terminated automatically when a transfer from the ion energy per unit charge level to the electron energy level occurs. The mode may also be terminated by ground command.

*5. Magnetometer (GSFC).* This instrument measures sequentially the magnitude of the three orthogonal components of the interplanetary magnetic field. The magnetometer has a range of $\pm 64\ \gamma$.

The instrument has a single flux gate sensor and associated electronics. The sensor is mounted on the end of one of the three spacecraft booms, where the residual magnetic field of *Pioneer VII* was less than 0.5 $\gamma$. It is aligned perpendicular to the boom axis and at an angle of 54° 45″ to the plane containing the boom and spin axis. Thus at any three positions separated by 120 deg of spacecraft rotation, the sensor direction at one position is orthogonal to that at the other two positions. The sensor consists of a saturable magnetic core which is excited at 13 kHz from positive to negative saturation by a solenoidal drive coil. The magnitude of the second harmonic 26-kHz signal measured by a tuned amplifier connected to a secondary coil winding is proportional to the component of the external magnetic field along the sensor axis and the permanent magnetization of the core itself. A mechanical flip mechanism which rotates the sensor through 180 deg permits detection and, thus, elimination of the latter effect. The flip mechanism contains 22 small squibs grouped in pairs for redundancy. Each squib of a pair, when individually fired, releases a spring with an escapement mechanism to reverse the direction of the sensor by precisely 180 deg. Each pair of squibs is activated by ground command.

The instrument is capable of four different data recording sequences. When the spacecraft is transmitting at 64 bits/s and higher, three orthogonal measurements are taken in a single rotation; each measurement is stored as an 8-bit word, and the measurements are telemetered in a group of 24 bits. The cycle repeats continuously. When the spacecraft is transmitting at 16 bits/s, measurements for each of the three positions are made and stored during each of four consecutive spacecraft rotations and the average value at each position is telemetered. The cycle repeats continuously. At 8 bits/s, measurements are averaged for eight revolutions of the spacecraft. When the spacecraft is operating in *duty cycle store* mode, the number of measurements averaged is:

| Time to fill, h | Number of component measurements |
|---|---|
| 2.4 | 64 |
| 4.8 | 128 |
| 9.5 | 256 |
| 19.0 | 256 |

The instrument can be commanded into a *calibrate* mode from the ground. In this mode a bias voltage is furnished to the sensor corresponding to a 10-$\gamma$ magnetic field offset. The instrument remains in the *calibrate* mode for 3584/(spacecraft bit rate) seconds and then returns automatically to the appropriate data recording mode.

*6. Radio propagation (Stanford University).* This experiment involves the transmission of two modulated coherent carriers of approximately 49.8 and 423.3 MHz from the ground and the reception of these signals by receivers aboard the spacecraft. The receivers are designed to measure the relative phase of the modulation envelopes of the two carrier frequencies which, since the higher frequency is relatively unaffected by the presence of ionization, provides a value for the integrated electron density. In addition, the rate of change of phase of one carrier with respect to the other is measured, thus accurately determining the time variation of the integrated electron density. Signal strength is also measured.

The instrumentation for this experiment consists of two ground-based transmitters operating into a 150-ft-diam parabolic antenna located on the Stanford campus, a dual-channel, phase-locked-loop receiver aboard the spacecraft, the spacecraft telemetry, and the DSN. All of the elements of the system just described must operate simultaneously to provide a closed-loop operation.

From the ground, this instrument can be placed into a *calibrate* mode. The purpose of this mode is to obtain a calibration point on the modulation phase detector. The mode effects this by strapping the inputs of the two receiver IF strips together and connecting them to the output of the high-frequency RF mixer. The difference frequency count will then be zero. The relative phase

of the modulation frequency between the two channels will also be read. The *calibrate* mode is terminated automatically.

7. *Astronomical constants.* The object of this experiment is to use the available tracking data from all of the *Pioneer* missions to obtain primary determinations of the masses of the earth and moon, the astronomical unit, and the osculating elements of the orbit of the earth. *Pioneer* data are appropriate for this experiment because of the absence of midcourse orbit corrections and near-planetary encounters. In addition, solar-radiation-pressure effects are small for the *Pioneer* configuration.

The experiment does not require any additional on-board equipment, but makes use of the on-board receiver and transmitter equipment in conjunction with DSS equipment to obtain two-way doppler measurements.

N70-28132

## II. *Pioneer VII* TDS Requirements

### A. *Pioneer VII* TDS Near-Earth Phase Requirements

The TDS near-earth phase support for *Pioneer VII* consisted of the committed facilities of AFETR, GSFC, and portions of the DSN. The tracking and data acquisition coverage requirements placed upon AFETR and GSFC are treated in the following paragraphs. The requirements originate from the following areas: (1) *Pioneer VII* mission requirements, (2) launch vehicle requirements, and (3) range safety requirements.

As a result of the importance of the AFETR acquisition support to the DSN, the tracking requirements placed upon AFETR are classified and defined as follows:

Requirements are class I and reflect the minimum essential needs to insure accomplishment of primary test objectives. These are mandatory requirements which, if not met, may result in a decision not to launch.

During the launch phase of any space mission, i.e., from launch to the initial DSIF acquisition, several events occur which have a major influence upon the success of the mission. For example, all of the powered flight and separation events occur which lead to the injection of the spacecraft into its deep space trajectory and the subsequent final separation of the spacecraft from the launch vehicle third stage. The information gathered from tracking and telemetry during this period is used to continually evaluate and update the status of the flight.

As explained, acquisition support by AFETR is important to successful initial acquisition by the committed DSN station. This AFETR acquisition support effort was primarily directed toward evaluating the performance of the launch vehicle including the third-stage burn (initial DSN acquisition occurs subsequent to third-stage burn). In addition to being vital to the acquisition effort, near-real-time evaluation of launch vehicle performance is of concern to spacecraft personnel. For example, should the launch vehicle performance be nonstandard during any portion of powered flight, and if an indication of the degree of abnormality of the flight can be obtained soon enough, there would exist an opportunity to change the command sequence of the spacecraft events so as to maximize the likelihood of meeting the flight test objectives.

There are two general methods of evaluating the launch vehicle performance in near-real-time. One method involves comparing the actual *mark* times of the significant launch vehicle events from telemetry with the predetermined nominal times and analyzing the differences. This method includes the general evaluation of all available telemetry. The other method requires tracking data in order to calculate the resultant trajectory subsequent to the first- and second-stage burn (*Thor/Delta*). A comparison then of the actual trajectory with the anticipated nominal gives an evaluation of the launch vehicle performance. By employing both of these methods, one can be used to determine the validity of the conclusions derived from the other.

The actual launch vehicle *mark* times for the *Pioneer* launches were determined by AFETR from telemetry received at AFETR sites and reported by the supervisor of range operations (SRO) over AFETR communications networks. In the launch vehicle telemetry laboratory, located in Building AE, the telemetry data was analyzed and the *mark* times validated. The mission analyst located at Building AE also provided current reports to JPL regarding the launch vehicle performance based on all information available to him in real-time, including *mark* times.

The accuracy to which the first and second stages injected the combination third stage/spacecraft into the parking orbit was evaluated by tracking the *Delta*-stage

C-band beacon by AFETR and MSFN radars subsequent to injection into the parking orbit. Trajectory calculation by the AFETR performed at the Real Time Computing Complex (RTCC) based on this tracking data was used to establish the degree of normality of the parking orbit. This evaluation was done by the flight path analysis group at the SFOF after receiving the parking orbit elements and injection conditions from the RTCC.

Determining the performance of the third stage by AFETR in near-real-time is a much more difficult task since this stage is not equipped with a radar tracking beacon. Two methods have been conceived, however, which provide some indication of third-stage ignition and burn duration. One method involves examining the doppler in the RF signal on the carrier of the spacecraft S-band telemetry. The other method is dependent upon receiving a signal from the beacon installed on the third stage and retransmitting this signal to Building AE for display and analysis of the doppler frequencies.

*1. AFETR acquisition support requirements.* The first major event accomplished by the DSN during a flight is that of initial acquisition of the spacecraft by a Deep Space Station. In order to accomplish this acquisition, the acquiring station (which in this case was DSS 51, but could possibly have been DSS 42) must know the approximate spacecraft trajectory in terms of station predicts[1] before the spacecraft comes into view. Predicts based upon nominal launch vehicle performance are furnished to all Deep Space Stations prior to launch. However, predicts based upon actual launch vehicle performance can be very useful during the initial acquisition by the DSIF, particularly if the performance is substantially different from nominal. Because of the time required to receive the tracking data from AFETR, calculate the predicts, and transmit them to the SFOF for retransmission to the Deep Space Stations, the most timely predicts are those based upon tracking data taken subsequent to injection into the parking orbit and a nominal third-stage burn. Only AFETR can supply these real-time predicts by utilizing tracking data from its radars and calculating the trajectory. If the trajectory is nominal, i.e., within specification, DSS 51 and 42 would have no trouble acquiring. However, should the spacecraft be injected into a nonstandard trajectory, it is necessary that real-time predicts generated by AFETR be available to both stations.

[1]Station predicts include declination, hour angle, and doppler detector output frequencies correlated with time.

Specified in this section are the minimum acceptable AFETR tracking period as well as station and communications requirements necessary to enable the AFETR to deliver predicts to JPL in near-real-time. The SRO commits AFETR to a launch and determines whether the requirements needed for support are satisfied, including those specified in this section. These minimum requirements have been included here to point out that if AFETR support is unavailable because of operational difficulties, this would preclude the possibility of receiving the predicts in real-time and might cause the DSN manager not to commit the DSN to the launch.

*2. AFETR class I tracking requirements.* The minimum requirement for tracking coverage is from SECO (sustainer engine cutoff) to SECO plus 60 s. Since SECO is considered as the injection point into the parking orbit, this tracking coverage constitutes 60 s of the parking orbit.

*3. AFETR station support requirements.* As a result of the combination of the trajectory characteristics and AFETR station locations, only Grand Turk and Antigua radars can view the launch vehicle/spacecraft combination subsequent to injection into the parking orbit. Thus, to be able to provide 60 s of tracking into the parking orbit, at least one of these stations must be operational. Since the parking orbit coverage by Grand Turk occurs very close to the station's horizon (approximately 2 min viewing time), the quality of the tracking data received may be questionable. It was, therefore, preferable to have data from Antigua since it has a better view: about 4 min of parking orbit track.

*4. Data processing support.* It was mandatory that the CDC 3600 computers at the RTCC be operational to enable AFETR to prepare DSIF station predicts. These computers process the raw tracking data, compute the parking orbit elements, compute the solar orbit elements based on a nominal third-stage burn, and compute the predicts.

For JPL support, the purpose of the CDC 3100 computer is to process octal raw tracking data into decimal data before it is sent to JPL. This permits the flight path analysis personnel at JPL to visually evaluate the data as it is being received. Since this is a recent improvement in the AFETR/JPL interface, JPL still has the capability to receive and process octal data; consequently, it is not considered mandatory that the CDC 3100 computer be able to support the launch.

*5. Communications Between Grand Turk and/or Antigua and RTCC.* For *Pioneer*, a high-speed data link was required between Grand Turk and/or Antigua and the RTCC for the transmission of radar raw data. Ordinarily the communications subcable is used; however, should the subcable be inoperative, other links providing the same capability would be necessary.

*6. Communications Between RTCC and Building AO at AFETR.* At least one voice line was mandatory for the coordinating of the JPL/RTCC interface. A minimum requirement of one teletype line between the RTCC and Building AO was to be satisfied for the transmission of the spacecraft frequency parameters from Building AO to the RTCC and the DSIF predicts from the RTCC to Building AO.

*7. Communications Between Building AO and the SFOF.* JPL/AFETR and JPL/Pasadena coordination required at least one cross-country voice line. A minimum of one duplex teletype line was to be available for the cross-country transmission of the spacecraft frequency parameters from the SFOF to Building AO and the AFETR-generated DSIF predicts from Building AO to the SFOF.

*8. Communications Between the spacecraft monitoring station (DSS 71) at AFETR and Building AO.* At least one teletype line was to be operational.

*9. Communications Between Building AE and the DSN/SFOF.* Since the mission director is located in Building AE, voice contact had to be maintained between the mission director (Cape Kennedy) and the DSN system manager (Pasadena). In case of a nonstandard communication situation, this requirement could be met with a black phone line between Building AE and the DSN/SFOF.

*10. Near-earth phase trajectory characteristics.* Real-time flight analysis of the near-earth phase of the flight, as well as the prelaunch countdown, was greatly facilitated by the ready access to launch window and trajectory information.

Listed in Table 4 are the nominal *mark* times from *mark 1* (thrust augmentation rocket jettison) to *mark 11* (spacecraft boom deployment). This table is included so that the actual *mark* times received from the AFETR in real-time can be compared with the nominal values.

**Table 4. Nominal *mark* events for the *Pioneer VII* mission**

| *Mark* | Event | Time from liftoff, s |
|---|---|---|
| 0 | Liftoff | L + 0 |
| 1 | Thrust augmentation rocket jettison | L + 70.0 |
| 2 | Main engine cutoff (MECO) | L + 149.2 |
| 3 | Second-stage ignition | L + 153.2 |
| 4 | Shroud jettison | L + 179.2 |
| 5 | Sustainer engine cutoff (SECO) | L + 551.1 |
| 6 | Third-stage spin-up | L + 1486.2 |
| 7 | Second-stage/third-stage separation | L + 1488.2 |
| 8 | Third-stage ignition | L + 1501.2 |
| 9 | Third-stage burnout = injection | L + 1523.7 |
| 10 | Third-stage/spacecraft separation | L + 1582.2 |
| 11 | Spacecraft boom deployment complete | L + 1583.5 |
| | Spacecraft TWT amplifier on | L + 1583 5 |
| | Type I orientation initiated | L + 1583.5 |

In order to present a clear composite picture of the near-earth phase of the station coverages in relation to flight events and coverage requirements, an earth track of the trajectory up to about the first 15 h from launch is plotted in Fig. 5. An elevation constraint of 0 deg has been applied to the AFETR stations and 5 deg for the Deep Space Stations.

*11. S-band telemetry.* A program requirements document provided the AFETR S-band requirements. The data to be recovered during the launch phase were 64 bits/s PCM, bi-phase modulating a 2048-Hz subcarrier. This phase modulated the S-band carrier 0.9 rad peak. The transmitter output was stated as 40 mW. Support requirements were based upon transmitting antenna gains between 0 and −21 dB.

*12. Metric data.* During the near-earth phase, the required class I, II, and III metric data was to be provided by AFETR C-band monopulse radars with 29-ft Cassegrain reflectors, transmitting and receiving at 5400–5900 MHz. Continuous acquisition throughout the launch interval was to be provided by AFETR radars: FPQ-6 at Patrick Air Force Base, FPS-16 C-band monopulse radar with a 12-ft parabolic reflector at Cape Kennedy, and FPQ-6 at Antigua as well as the MSFN Bermuda station's FPQ-6 radar.

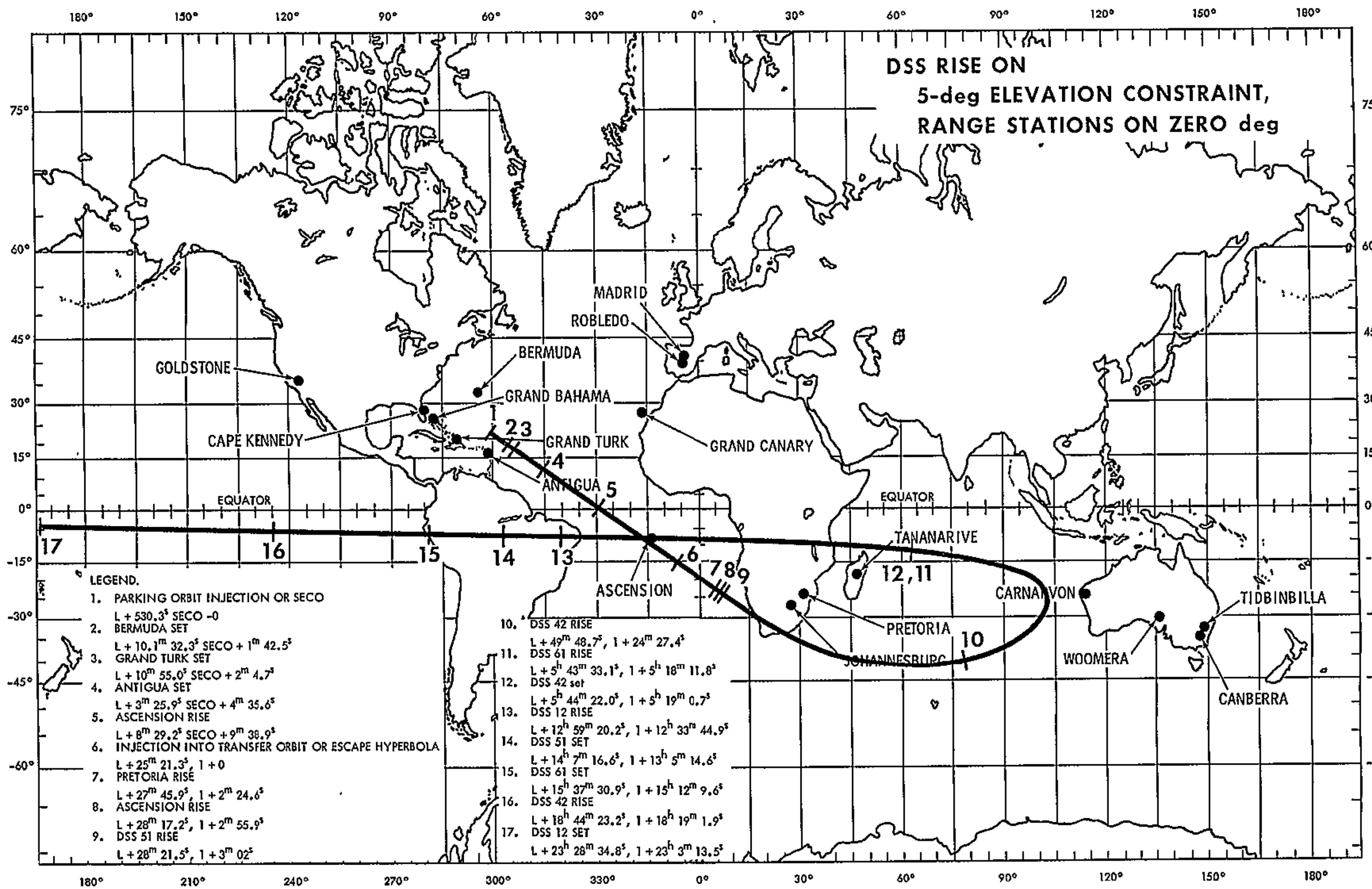


Fig. 5. *Pioneer VII* earth track

The AFETR range instrumentation ship (RIS) *Sword Knot* and the MSFN stations at Tananarive and Carnarvon were required to meet the class I requirement of determining orbital elements and injection conditions of solar orbit by continuous tracking for 50.2 s, starting from third-stage engine cutoff.

Figure 6 shows the metric data tracking intervals for beacon and skin tracking modes.

The AFETR stations at Pretoria and Antigua had the responsibility to provide class II coverage of continuous spacecraft telemetry data from $T - 3$ min to shroud ejection and from SECO + 100 s to third stage spin-up to loss of signal (LOS) by AFETR stations.

DSN 71 at Cape Kennedy was required to provide S-band spacecraft telemetry from $T - 8$ min to LOS as an aid to acquisition of signal by other Deep Space Stations. The received telemetry data was to be demodulated, sampled, and formatted by the GOE and SDS-910 computer at DSS 71 and sent by teletype to the SFOF.

Johannesburg, DSS 51, was to attempt to make initial acquisition of the spacecraft S-band telemetry signal,

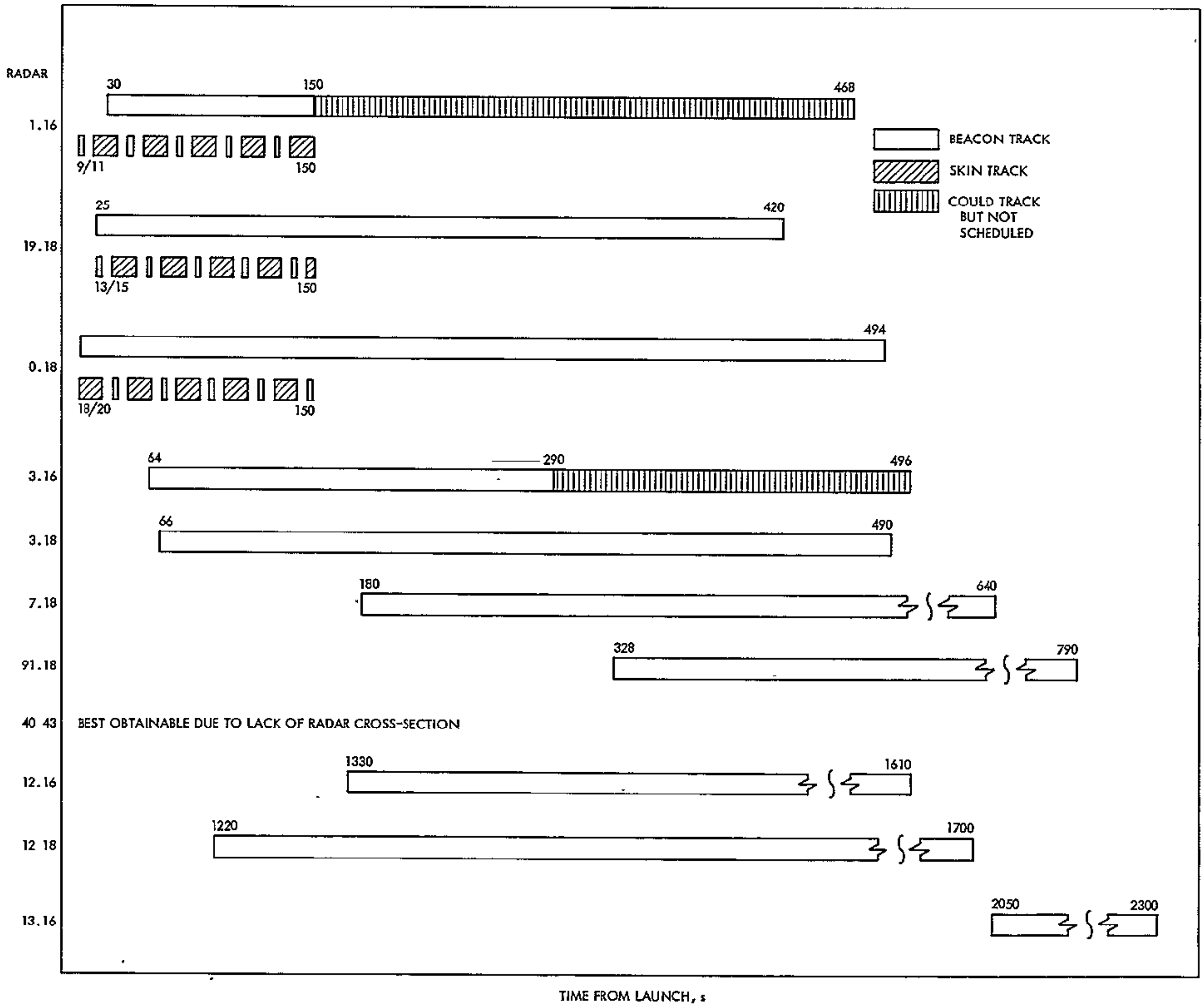


Fig. 6. Metric data tracking interval, pulse systems

from $L + 31$ min to $L + 44$ min (nominal). The prime acquisition station at Woomera, DSS 41, was to supply continuous telemetry data from accomplishment of acquisition, at approximately $L + 49$ min, thus completing the near-earth phase support.

*13. VHF telemetry.* Based upon the support requirements of AFETR and MSFN, during the near-earth phase data acquisition of VHF telemetry was dependent upon various AFETR and MSFN stations. The class I requirement of continuous *Thor/Delta* VHF launch vehicle telemetry from launch to SECO + 130 s and from third-stage spin-up to third-stage separation was dependent upon the coverage provided by AFETR stations at Cape Kennedy (Telemetry 2), Grand Bahama Island, and Antigua. Additionally, the MSFN stations at Bermuda and Tananarive were to provide coverage to assure meeting class I requirements.

*14. Near-earth phase.* During the near-earth phase, class I S-band spacecraft telemetry requirements of continuous spacecraft telemetry data from shroud ejection to SECO + 120 s and from third-stage spin-up to third-stage ignition were to be supplied by AFETR stations at Cape Kennedy (Telemetry 2) and Grand Bahama Island and the MSFN station at Grand Canary Island.

Table 5 gives the stage 2 predicted telemetry coverage for *Pioneer VII*.

*15. Class I requirements.* The class I S-band telemetry requirements included the receiving and recording of the spacecraft data from shroud jettison to SECO + 120 s and from third-stage spin-up to third-stage burnout + 80 s. These values correspond to range times of $T + 175.5$ to $T + 649$ s and $T + 1460$ to $T + 1600$ s. In addition, all downrange S-band stations and ships which received the *Pioneer* spacecraft telemetry signal were required to provide to the SRO, in near-real-time, a voice report of time of acquisition of signal (AOS), time of loss of signal (LOS), and signal strength of the S-band carrier.

*16. Class II requirements.* Class II requirements included the receiving and recording of the spacecraft data from $L - 3$ min to $T + 175.5$ s (shroud jettison), from $T + 529$ to $T + 1590.5$ s, and from $T + 1590.5$ s to LOS of AFETR station.

Figure 7 shows the composite AFETR tracking and acquisition commitments for the *Pioneer VII* mission. Table 6 gives the AFETR telemetry data commitment for *Pioneer VII*.

*17. Operational support.* The JPL/AFETR field station located at Cape Kennedy was to support the launch phase operations of *Pioneer VII* by providing the necessary operational interface between the DSN/SFO in Pasadena and AFETR and other project elements at AFETR. This operational interface comprised the following activities:

(1) Monitoring (a) the status of AFETR stations, ships, and equipment, (b) progress through the countdown, and (c) the occurrence and time of in-flight events. (Launch vehicle and spacecraft status is reported by *Pioneer* project office personnel from the Mission Control Center in Building AE.)

(2) Providing liaison between the Flight Path Analysis and Command (FPAC) group and the AFETR Real Time Computer Facility (RTCF) through the JPL data coordinator stationed at the RTCF.

(3) Receiving, and retransmitting to the SFOF, AFETR metric tracking data and computed data, including injection conditions, orbital elements, and DSIF acquisition information.

(4) Relaying spacecraft telemetry data from DSS 71 to the SFOF, and to Building AM.

(5) Receiving from the SFOF, and retransmitting to Building AM, spacecraft telemetry data from DSS 51.

In addition to the launch phase operations, the field station participated in the prelaunch integration tests and operational readiness tests. These tests essentially duplicated the launch phase activity, with operations being simulated where necessary, and used the same personnel, equipment, and facilities.

### B. *Pioneer VII* TDS Deep Space Phase Requirements

Since the requirements placed upon the systems comprising the DSN are in support of the DSN commitments to the *Pioneer* project, it is appropriate to state the following basic commitments:

DSS 12 or 14—one complete pass per day during entire life of the mission.

DSS 42—one complete pass per day for the first 30 days of the mission.

## Table 5. Predicted stage 2 telemetry coverage

| Station | Acquisition of signal, s | Gaps (±), s | Loss of signal, s |
|---|---|---|---|
| Cape Kennedy | 0 | | 500 |
| Grand Bahama | 34 | | 530 |
| Bermuda | 194 | | 630 |
| Antigua | 278 | | 806 |
| | | 23 | |
| Aircraft | 829 | | 1116 |
| Ascension | 1130 | 14 | 1770 |
| Pretoria | 1742 | | 2586 |
| Tananarive | 2046 | | 2870 |
| | | 84 | |
| Carnarvon | 2954 | | 4046 |
| | | 804 | |
| Hawaii | 4850 | | 5614 |
| Western Test Range | 5510 | | 6134 |
| Texas | 5900 | | 6440 |
| Cape Kennedy | 6162 | | 6598 |
| Grand Bahama | 6202 | | 6642 |
| Antigua | 6500 | | 6930 |
| | | 400 | |
| Ascension | 7334 | | 7902 |
| | | 20 | |
| Pretoria | 7922 | | 8852 |
| Tananarive | 8250 | | 9206 |
| Carnarvon | 9246 | | 10,106 |
| | | 1064 | |
| Hawaii | 11,170 | | 11,765 |
| Western Test Range | 11,742 | | 12,222 |
| | | 1464 | |
| Ascension | 13,686 | | 14,066 |
| | | 40 | |
| Pretoria | 14,106 | | 15,150 |
| Tananarive | 14,430 | | 15,522 |
| | | 1904 | |
| Hawaii | 17,426 | | 17,962 |
| Cape Kennedy | 0 | | 500 |
| Grand Bahama | 34 | | 530 |
| Bermuda | 194 | | 630 |
| Antigua | 278 | | 806 |
| | | 320+ | |
| Range instrumentation ship | * | | * |
| Ascension | 1130 | | 1697 |
| | | 100+ | |
| Pretoria | 1742 | | 2586 |
| Tananarive | 2046 | | 2870 |
| | | 100 | |
| Carnarvon | 2954 | | 4046 |
| | | 850 | |
| Hawaii | 4850 | | 5614 |
| Western test Range | 5510 | | 6134 |
| Texas | 5900 | | 6440 |
| Cape Kennedy | 6162 | | 6598 |
| Grand Bahama | 6202 | | 6642 |
| Antigua | 6500 | | 6930 |
| | | 400 | |
| Ascension | 7334 | | 7902 |
| | | 20 | |
| Pretoria | 7922 | | 8852 |
| Tananarive | 8250 | | 9206 |

Coverage: 5000 s of first 6000 s; 2/3 of complete 3 orbits

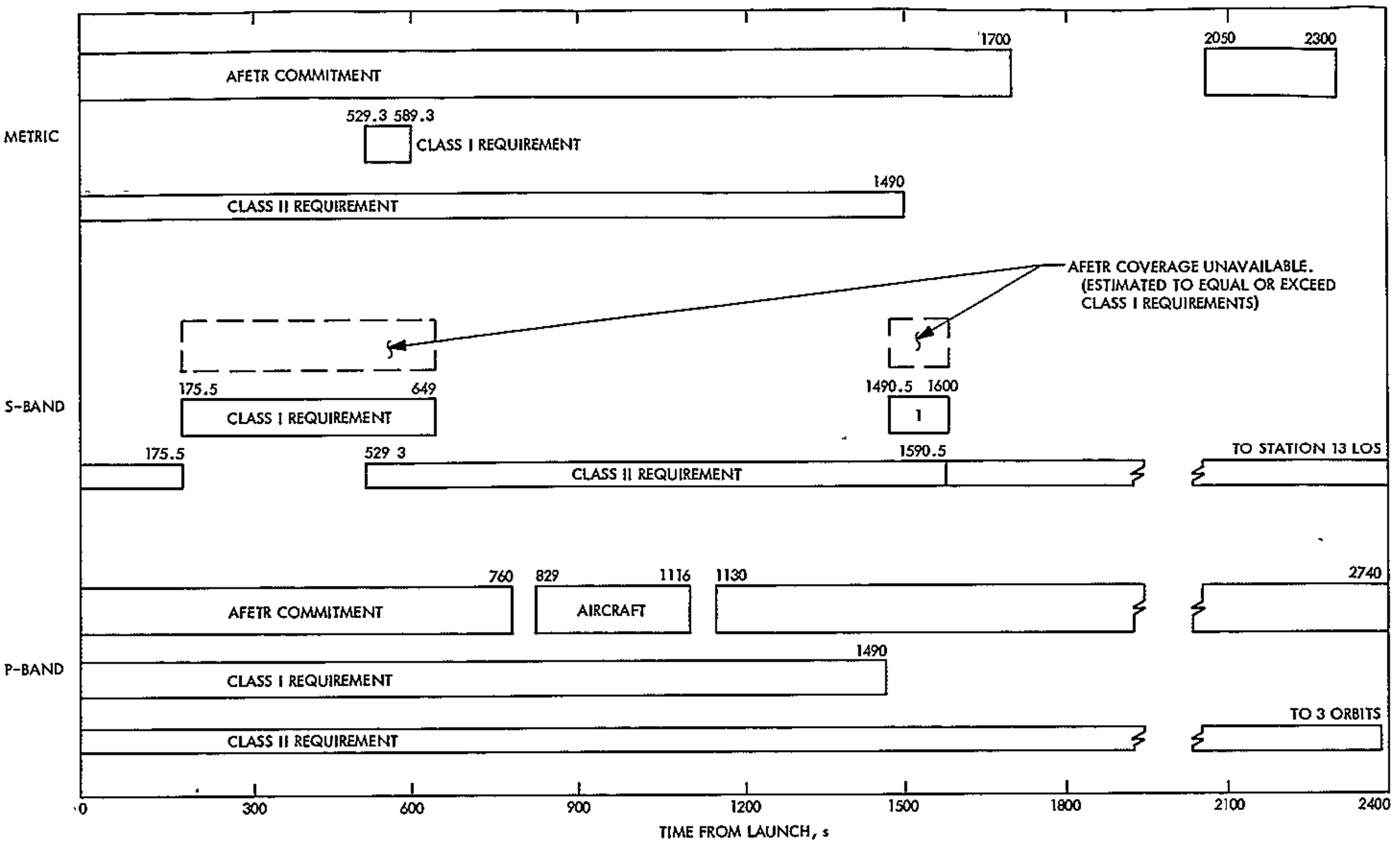


**Fig. 7. Composite AFETR tracking and acquisition commitment**

DSS 51—one complete pass per day for only the first four days of the mission.

DSS 71—compatibility, integration, and operations tests for 30 days prior to launch.

DSS 12 was to be fully equipped with mission-peculiar ground operational equipment including specialized display equipment to provide command, telemetry, partial telemetry data processing, and equipment checkout capability throughout the mission, including the orientation phase. Station equipment was to be available for *Pioneer* use during compatibility and performance tests, operation readiness activities, and flight operations rehearsals. The station was to be operational for *Pioneer* during launch countdown and was to provide command, telemetry and tracking coverage, and partial data processing for a complete pass of the spacecraft on a daily basis during the first month following launch and for a minimum of three days per week thereafter. When possible, full weekly coverage was desired during this latter phase.

DSS 42 was to be equipped with mission-peculiar ground operational equipment to provide command, telemetry, partial data processing, and equipment checkout capability throughout the mission, but was not to contain specialized display equipment required during the orientation phase. Station equipment was to be available for *Pioneer* use during performance tests, operation readiness activities, and flight operations rehearsals. The station was to be operational for *Pioneer* during the launch countdown and was to provide command, telemetry, tracking coverage, and partial data processing for a complete pass of the spacecraft on a daily basis during the first month following launch. Thereafter, maximum coverage was desirable whenever possible.

DSS 51 was to be equipped with mission-peculiar ground equipment to provide command, telemetry, partial data processing, and equipment checkout capability throughout the mission, but was not to contain specialized display equipment required during the orientation phase. Station equipment was to be available for *Pioneer* use during performance tests and operation readiness

**Table 6. AFETR telemetry data commitment**

| Station | Link | Commitment |
|---|---|---|
| Cape Kennedy (Tel 2) | 228.2 | $T-120$ s to stage 1 separation, exclusive of staging dropouts |
| | 234.0 | $T-120$ to $T-466$ s, exclusive of staging and flame dropouts |
| Grand Bahama | 2292[a] | To be provided by teletype test instructions |
| | 228.2 | $T+56$ s to stage-1 separation plus 5 s |
| | 234.0 | $T+56$ to $T+508$ s, exclusive of noise due to flame |
| | 2292[a] | To be provided by teletype test instructions |
| Antigua | 234.0 | $T+320$ to $T+760$ s |
| | 2292[a] | To be provided by teletype test instructions |
| Ascension Island | 234.0 | $T+1130$ to $T+1770$ s |
| | 2292[a] | To be provided by teletype test instructions |
| Pretoria | 234.0 | $T+1745$ to $T+2740$ s |
| Range instrumentation ship (if available) in the vicinity of Station 12 | 234.0<br>2292[a] | To be provided by teletype test instructions |

[a]Link 2292 commitment is limited-data commitment at Cape Kennedy, Grand Bahama, Antigua, Ascension, and range instrumentation ships, because the receivers, preamp-down converters, and antennas have not been acceptance-tested.

activities. The station was to be operational for *Pioneer* during the launch countdown and was to provide command, telemetry, and tracking coverage for a complete pass of the spacecraft on a daily basis during the first two weeks following launch. Thereafter, maximum coverage was desirable whenever possible.

DSS 71 was to be equipped with mission-peculiar equipment to provide command, telemetry, and partial data processing capability only. Station equipment was to be available for *Pioneer* use during spacecraft/Deep Space Station compatibility tests for six weeks prior to launch.

DSS 11, DSS 41, and DSS 61 were not to be equipped with mission-peculiar equipment. It was requested that these stations track and receive telemetry data and record the telemetry subcarrier on magnetic tape as a backup whenever other DSIF stations having *Pioneer* equipment are unable to track the spacecraft.

At all stations supporting the *Pioneer* mission, equipment was required to receive telemetry at S-band from deep space and record the telemetry subcarrier on FR-1400. At the stations supplied with mission-peculiar equipment, the DSIF was to furnish an SDS 910/920 computer and peripheral equipment for partial data processing, terminal communications equipment to permit voice from the station and teletype information from the computer to the SFOF, and equipment to transmit, verify, and monitor commands at S-band to the spacecraft.

An area of approximately 400 ft$^2$ or greater was to be available for mission-peculiar equipment at DSS 12. An area of approximately 300 ft$^2$ or greater was to be available for *Pioneer* mission-peculiar equipment at DSS 42, DSS 51, and DSS 71. Each area was to contain 110-V ac power outlets, have the capability of providing cooling air for the *Pioneer* equipment, and provide a junction box within 25 ft of the *Pioneer* equipment through which all connections between *Pioneer* and Deep Space Station equipment will be made. Areas at DSS 12, 42, and 51 were also to contain a storage cabinet (minimum size: shelf area, 24 ft$^2$, shelf depth, 24 in., shelf height, 15 in.) and at least one standard four-drawer file.

The following intrastation voice communication was to be available:

Goldstone.

| | |
|---|---|
| Orientation director | Station manager |
| Spacecraft status advisor | Receiver operator |
| | Transmitter operator |
| | Antenna operator |
| | Data handling operator |

Canberra and Johannesburg.

| | |
|---|---|
| GOE command operator | Receiver operator |
| | Data handling operator |
| | Transmitter operator |
| | Antenna operator |

Teletype and voice lines for the *Pioneer* Project were as shown on Fig. 8. The DSN was responsible for providing the communication requirements shown in Fig. 8 between the DSIF and SFOF. ARC was responsible for providing the communications shown between SFOF and NASA/ARC, STL, and Stanford University.

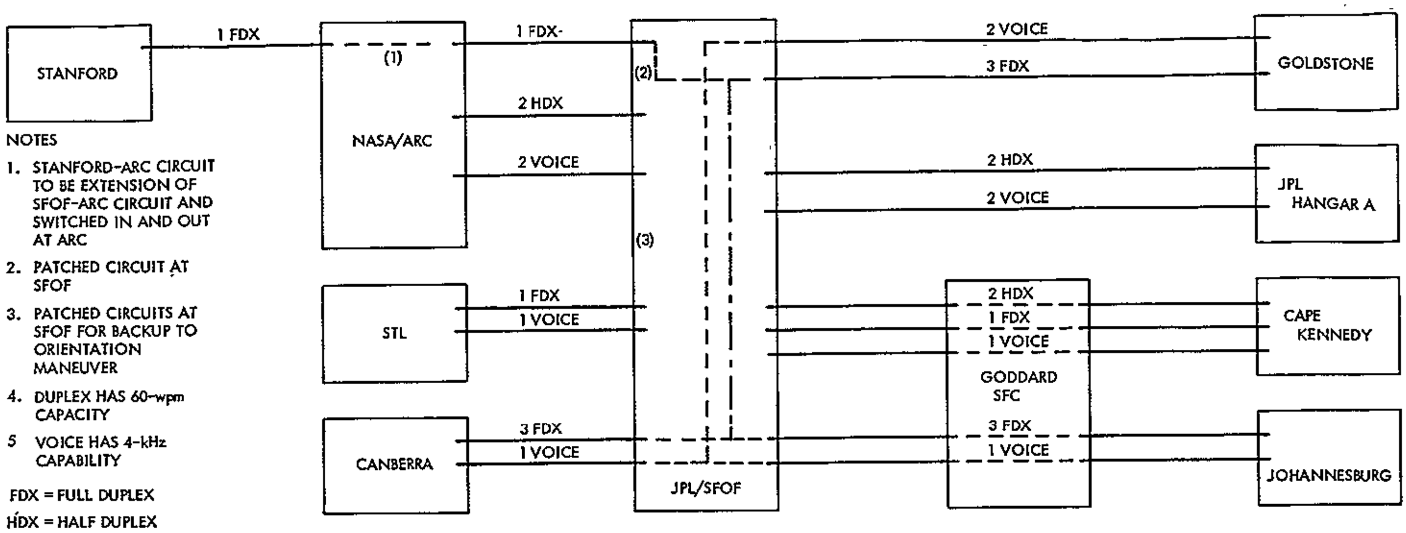


**Fig. 8. *Pioneer VII* intrastation communication requirements**

The DSN was to provide the terminal equipment at the DSIF and SFOF required to transmit and receive the voice and teletype messages and to record the teletype messages at both transmittal and reception terminals on tape and printout formats.

The DSN was to provide personnel, facilities, equipment, and supplies required to accomplish the tasks defined herein.

The DSIF was to receive, inspect, install, and check out mission-peculiar equipment.

The DSIF was to prepare for use and operate during compatibility and performance tests mission-independent equipment required. In cooperation with ARC and STL personnel, the DSIF was to operate the mission-peculiar equipment during these tests.

The DSIF was to prepare for use and operate during flight operations rehearsals and operational readiness activities mission-independent equipment required. In cooperation with ARC and STL personnel, the DSIF was to operate the mission-peculiar equipment during routine operations rehearsals and operational readiness activities. During rehearsals of the orientation maneuver, ARC and STL personnel were to operate the mission-peculiar equipment at DSS 12.

Station 71 was to report countdown status and launch sequence data to the SFOF during prelaunch operations and until initial acquisition by DSS 51.

The DSIF was to prepare for use and operate both mission-peculiar and mission-independent equipment during all flight operations except orientation maneuvers. During orientation maneuvers, ARC and STL personnel would operate mission-peculiar equipment. Station 71 was to transmit to SFOF range tracking data during the launch phase of the mission.

The DSIF was to keep an operation and maintenance log for the mission-peculiar equipment.

Personnel from ARC and STL were to be present at DSS 12 to aid in the installation and checkout of mission-peculiar equipment, to train DSIF personnel in the maintenance and operation of the equipment, to operate the mission-peculiar equipment during compatibility tests and rehearsals of the orientation maneuver, and to aid in operation of mission-peculiar equipment during rehearsals of routine flight operations. It was expected that as many as 20 persons might be present at a single time during performance of these tasks.

Personnel from ARC and STL were to be present at DSS 42 and 51 to aid in the installation and checkout of mission-peculiar equipment, to train DSIF personnel in the maintenance and operation of the equipment, to operate the equipment during performance tests, and to aid in the operation of the equipment during rehearsals. It was expected that no more than four persons would be present during performance of these tasks.

Personnel from ARC and STL were to be present during the orientation maneuver to operate the mission-peculiar equipment, including the specialized display used during this activity. It was expected that no more

than 10 persons would be present during this task. During routine flight operations no personnel from ARC or STL were to be on duty at DSS 12.

*1. Deep Space Stations.*

*a. Equipment.* The following equipment was operational at the committed Deep Space Stations:

(1) Project-dependent equipment (GOE):
Command encoder.
Demodulation synchronizer.
Computer buffer.

(2) Exciter.

(3) Transmitter.

(4) Receiver.

(5) Modulator.

(6) Diplexer.

(7) Acquisition aid antenna system.

(8) SCM antenna system.

(9) Maser.

(10) FR-1400 tape recorders.

(11) SDS-910 computer.

(12) Frequency and timing system.

*b. DSIF data validation.* In order to insure maximum performance of DSIF systems, requirements exist for the following items:

(1) Data required by Deep Space Stations prior to each *Pioneer* mission:

(a) Predictions consisting of antenna angles, transmitter VCO frequency, receiver VCO frequency, doppler frequency vs time.

(b) Telemetry test tapes.

(c) Tracking data test tapes.

(d) Command tapes.

(e) Telemetry calibration book.

(f) AFETR and CCF predictions (launch only).

(g) Required command system modulation index.

(2) Calibration data required from Deep Space Stations prior to each *Pioneer* mission:

(a) System noise temperature.

(b) Optical boresight angle readouts.

(c) RF boresight shift vs polarization.

(d) RF boresight vs signal strength ($-100$, $-110$, $-120$, $-130$, $-140$ dBmW) (DSS 11, 42, 51).

(e) Receiver threshold at 12-, 48-, and 152-Hz bandwidth.

(f) Receiver threshold at 120-, 255-, and 550-Hz bandwidth.

(g) Telemetry channel thresholds (75% in lock signal level).

(h) Test transponder serial number used in tests.

(i) Loss from test transponder output connector to low-noise amplifier input connector.

(j) Signal level vs AGC volts and channel 6 VCO frequency from $-90$ dBmW to threshold in 5-dB steps.

(k) Star tracking data.

(l) Antenna gain.

(m) Maser gain.

(n) Parametric amplifier gain.

(o) Loss from feed output connector to low-noise amplifier input connector.

(p) Antenna patterns.

(q) Feed ellipticity.

(3) Recorded data (other than magnetic recordings), labeled with:

(a) Station identification.

(b) Time (GMT) of the start and finish of the recording.

(c) Day of the year when the recordings were done.

(d) Recording identification.

(e) The mission designator.

(4) Station calibration and checkout sheets, labeled with:

(a) Station identification.

(b) Date of recording.

(c) Purpose of data (i.e., precalibration, postcalibration).

(d) Time (GMT) of recording.

(e) Name of operator.

(f) The mission designator.

*c. Quality control of data.* Tracking data monitoring for the *Pioneer* Project was conducted in three phases as follows:

(1) Phase 1—$L$ to $L + 3$ days.

(2) Phase 2—$L + 3$ days to $L + 30$ days.

(3) Phase 3—$L + 30$ days to end of mission.

Data monitoring was performed during each of these phases as outlined in Table 7.

**Table 7. Data monitoring phases**

| Phase | Monitor area[a] | Monitor frequency |
|---|---|---|
| 1 — $L$ to $L$+3 days | A | Continuous |
| | B | Every 4 h ($L$ to $L$+20 h) |
| | B | Every 8 h ($L$+20 to $L$+72 h) |
| 2 — $L$ +3 days to $L$ +30 days | B | Within 12 h of a 2-way pass |
| 3 — $L$ +30 days to end of mission | B | Within 72 h of a 2-way pass |

[a]A = Goldstone computer facility, B = SFOF.

Tracking data was monitored continuously in near-real-time at the Goldstone computer facility during phase 1 only. Data was monitored for high-frequency noise and compared with predicted data using the Goldstone prediction and monitor programs. The orbit determination program was used to validate tracking data for the project within the SFOF during all phases.

The purpose of near-real-time monitoring at the Goldstone computer facility is to monitor the tracking data and provide near-real-time performance feedback to the Deep Space Station during critical periods. The philosophy of metric data monitoring after $L + 3$ days is to inform the Deep Space Station of any metric data problems before the next two-way pass. Validation of data by the orbit determination program is checked for low-frequency noise and small biases between stations that cannot be detected by monitor of each station independently.

Telemetry data monitoring, on a random basis, was to be performed by the operator at the Deep Space Station (Fig. 9). The nonreturn-to-zero change data and sync status from both the *Pioneer* GOE and the reproduce head of the FR-1400 tape recorder were to be recorded on the CEC oscillograph. In addition, a dual-beam oscilloscope was to be connected to both the FR-1400 input and reproduce output of the 2048-Hz telemetry data stream.

The CEC recorder provided a record of the Deep Space Station receiver in-lock and out-of-lock history and FR-1400 recording history. The real-time analysis of the FR-1400 recording performance was to be made by the analog instrumentation subsystem operator by a visual comparison of the telemetry data stream from the Deep Space Station receiver with that recorded on the FR-1400.

Summary reports concerning telemetry recovery were to be published weekly during the mission. This summary was to cover telemetry demodulator in-lock times for each pass and consisted of a tabulation of the percentages of gross coverage by station and net. These percentages are derived by abstracting receiver in-lock and out-of-lock times and demodulator in-lock times from the Deep Space Station posttrack reports. These times are added and then divided by each station's scheduled tracking period for each pass to give overall percentage coverage. This information was to be tabulated for each Deep Space Station for each pass. These reports were to also provide graphs of telemetry coverage.

The Deep Space Station would play back a random 10-min sample of each FR-1400 tape to verify that the *Pioneer* GOE could lock up to the recorded 2048-Hz telemetry stream. A summary of the tape playback performance was to be included in the data package forwarded to Operational Document Control (ODC) in the SFOF.

The Deep Space Stations employed a comprehensive log keeping and reporting system in order to provide a complete record of system performance. Any equipment outages or suspected malfunctions causing loss of data or loss of spacecraft signal were to be immediately reported by voice to Net Control and documented by teletype reports and station logs. The station pretrack reports, tracking reports, and posttrack reports reflect all equipment anomalies plus station parameters such as prepass calibration and postpass calibration of a Deep

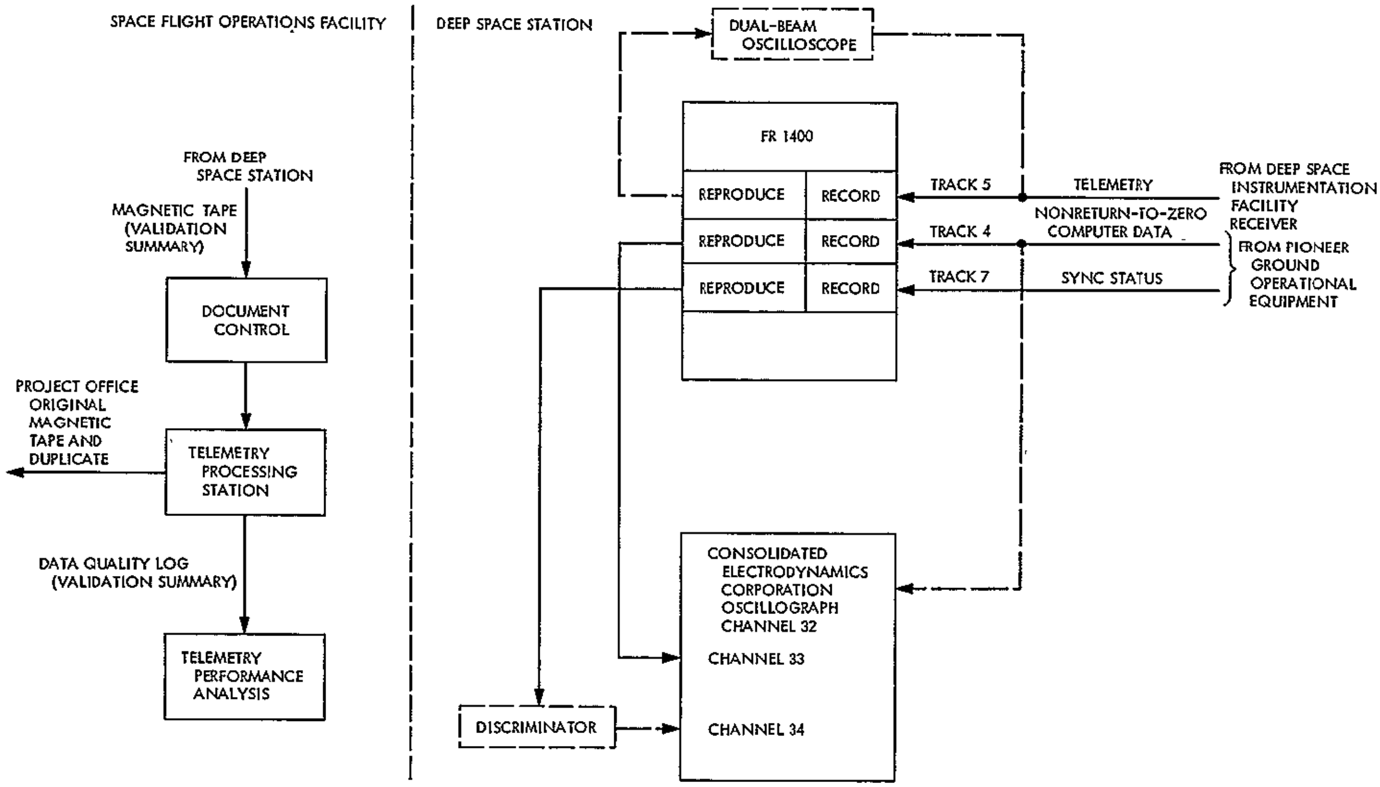


**Fig. 9. *Pioneer* telemetry data monitor**

Space Station. These reports spell out the Deep Space Station performance in support of the assigned mission before, during, and after all tracking passes. Station logs and Net Control logs further reflect in hours, minutes, and seconds all equipment failures or loss of data encountered during any single tracking pass. In addition, the operational voice circuits to the Deep Space Stations from Net Control are recorded by the JPL communications center.

In addition to preflight standard trajectory information and spacecraft telecommunication system design parameters, the *Pioneer* Project provided the DSN an indication of the normality of spacecraft injection in real-time for the purpose of assisting the initial acquisition of the spacecraft by the DSN. The DSN furnished a medium-accuracy orbit based upon tracking data received from the Deep Space Stations. The accuracy of this orbit was as follows:

(1) Injection: 10 km and 2-Hz two-way doppler.

(2) Injection + 10 days: 200 km and 5-Hz two-way doppler.

(3) Injection + 180 days: 1000 km and 5-Hz two-way doppler.

An orbit was furnished as soon as possible after launch and updated at least once a month.

*2. Ground Communications Facility.* Figure 10 is a schematic diagram of the planned communication lines. As indicated, the DSN internal communications requirements included communication lines between the committed Deep Space Stations and the SFOF. A minimum requirement was that there be at least two teletype circuits and one voice circuit operational between each Deep Space Station and the SFOF.

Communications circuits committed to support the *Pioneer* Project consisted of NASCOM circuits to the overseas stations and AFETR area and DSN circuits to Goldstone utilizing the JPL/GTS microwave link.

*a. NASCOM circuits.* Technical control of all NASCOM circuits is the responsibility of GSFC. This responsibility is defined as the continuous function of maintaining the continuity and integrity of the communications circuits.

The major policies and procedures used in accomplishing this are listed as follows:

(1) Provide and maintain sufficient order wire facilities to:

  (a) Remote facility control points.

  (b) Commercial and overseas carriers toll test centers and primary routing points.

  (c) JPL communications control for circuit and facilities coordination, trouble reporting, and fault location.

(2) Establish backup circuits and make-good facilities and prepare diverse routing plans.

(3) Establish working relationships with the various communications carriers, and establish mutual service restoral plans.

(4) Provide for the technical and administrative supervision of technical control centers at the primary switching and subswitching centers.

*b. Mission operations/control.* In conjunction with technical control, JPL (communications control) has the responsibility for mission operational control of all communications circuits used to support the *Pioneer* Project, including the entire DSN Ground Communications Facility as an entity, the communications centers at the remote stations, and the communications facilities linking them with the mission control center. The major policies and procedures used in accomplishing this responsibility are listed as follows:

(1) Insure that no marginal circuit is taken out of service for corrective action or for any other reason without the express approval of the space flight operations director or his authorized representative.

(2) Insure that all technical control tests and routine maintenance are performed on a noninterference basis with respect to mission simulations and flight operations.

(3) Insure that all mission and mission-related traffic has absolute priority on communications facilities dedicated for mission support.

(4) Provide facilities and personnel adequate to perform circuit quality monitoring, testing, and analysis of circuit performance. This is accomplished by utilizing:

  (a) Signal quality monitoring devices which serve as alarms and indicate when distortion levels of incoming data on teletype circuits exceed certain predetermined levels (normally 20 to 25% distortion).

  (b) A Stelma analyzer which provides distortion and bias readings as either average, peak, or individual (marking or spacing bias); provides scope presentation of an incoming or outgoing teletype signal for visual analysis; generates test patterns or individual letter tests at various speeds and desired amounts of distortion.

  (c) A comprehensive method of recording circuit outages using trouble tickets and communications center logs.

(5) Establish uniform and efficient DSN/GCF operating procedures and disciplines.

(6) Request and confirm special or critical coverage from cognizant agencies during critical periods of the *Pioneer* mission.

(7) Conduct circuit optimization testing on all circuits prior to release to the *Pioneer* Project for mission support.

(8) Conduct periodic circuit assurance tests on all idle circuits during mission support periods.

*c. JPL/GTS circuits.* The procedures and policies used in maintaining the quality of circuits to DSS 12 are identical, where applicable, to those outlined above. In addition, microwave alarms were available that indicated loss of pilot tone or any other type of microwave outages on either a group or a microwave channel. It was anticipated that utilization of the policies, procedures, and hardware outlined above and the addition of the signal quality monitoring and microwave alarms would result in optimum communications support of the *Pioneer* Project data validation effort.

*3. Space Flight Operations Facility.* This section briefly describes the requirements pertaining to the receiving and processing of *Pioneer* mission data tapes for quality control and validation that take place in the SFOF.

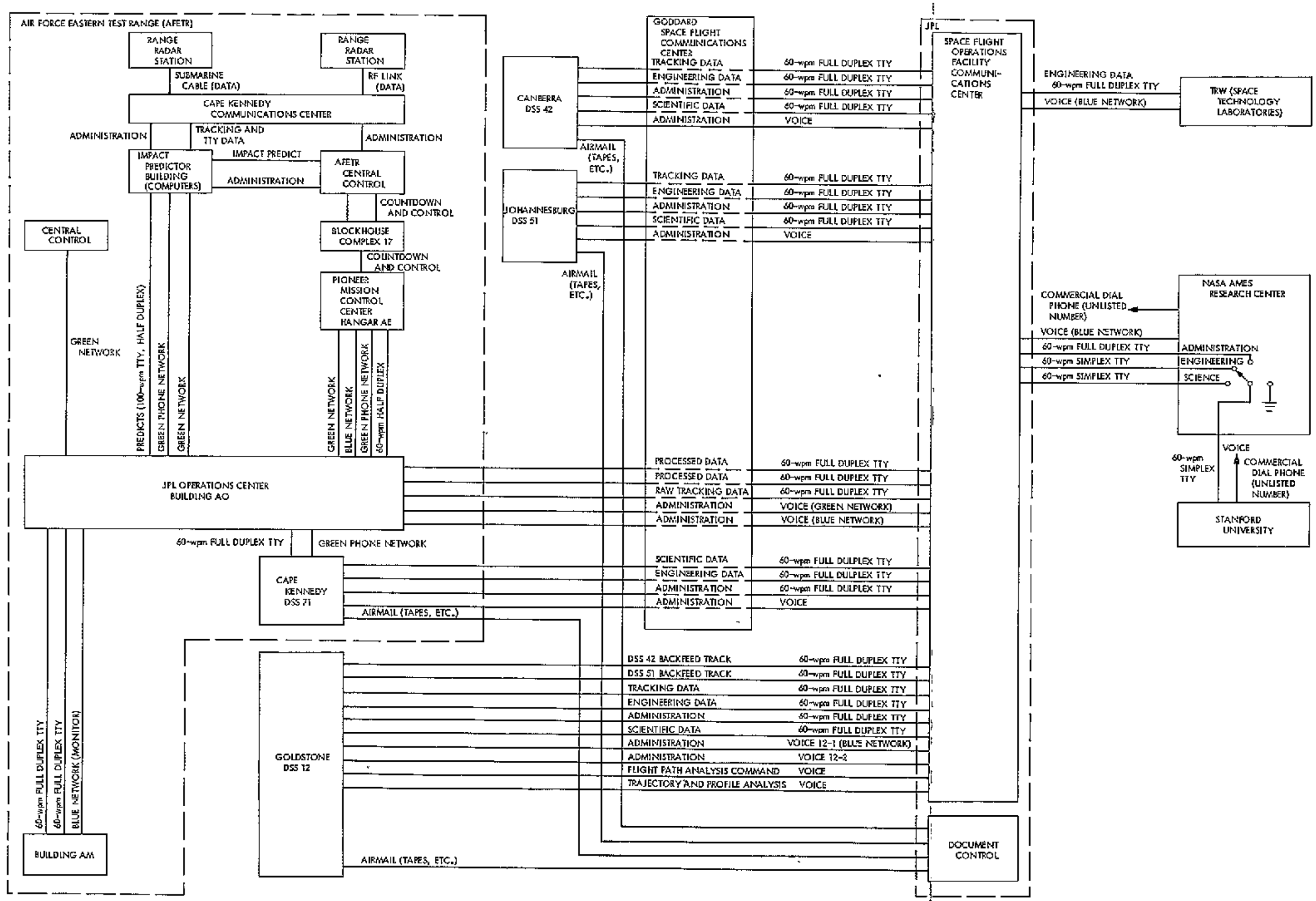


**Fig. 10. Communication lines, launch configuration**

*a. Operational data control.* Control of data coming into the SFOF from the Deep Space Stations is maintained to insure proper handling and distribution. This control is performed according to specified SFOF procedures.

*Tracking data.* Tracking data received is forwarded for distribution in the flight path analysis area (FPAA) and to the SFOD and assistant SFOD for purposes of trajectory computations, when required, in accordance with the commitment document. Validation is performed by flight path analysis personnel.

*Science data.* This data is separated from the engineering data subcommutator at the DSIF sites by the 910 computers and recorded on magnetic tapes. The tape is mailed to the SFOF and forwarded from there to ARC.

*Recorded data.* Magnetic tapes of recorded data are received from the Deep Space Stations in the SFOF. These tapes are forwarded to the telemetry processing station (TPS) for duplicating processing. After tape processing, TPS returns the original tape along with the duplicate and one copy of the data log for shipment to the *Pioneer* Project office at ARC.

*b. Telemetry processing station.* The TPS complex in the SFOF provides for the *Pioneer* Project one duplicate magnetic tape of each original Deep Space Station magnetic recording received. During the duplicating processing, TPS ascertains that the recording technique is correct and that telemetry data as well as station performance information is available. Further validation includes the following:

(1) Monitoring and verification of recording levels. The quality of a recording is determined by applying quality control devices such as spectrum analyzers and bit error detectors. A check is made to see that information is recorded in the proper standard being used by the Deep Space Station.

(2) Inspecting recorded data as to its continuity. A data time correlation is performed to determine that data dropout is not excessive or that data rates are not exceeding the limitations of processing equipment.

A data log on each tape is generated. This log contains the following indicators:

(1) Receiver flag (a time printout occurring each time there is a receive out-of-lock state).

(2) Demodulator flag (a time printout occurring each time there is a demodulator out-of-lock state).

(3) Time flag (an error printout occurring when delta time disagrees with data rate).

All data validation is done on the duplicated tapes.

After tape processing, the TPS returns the original tape with one copy of the data log for shipment to the *Pioneer* Project office. Copies of TPS validation reports are returned to the DSIF to be included in the station performance summary report.

*c. Computer.* At least one of the two computer strings in mode 2 must be operational. A computer string in mode 2 consists of an IBM 7044 computer and an IBM 7094 computer with a 1301 disc storage unit connected in tandem. This computer string is used by the flight path analysis and command (FPAC) team to:

(1) Compute acquisition prediction information for use by the Deep Space stations and the Stanford tracking station.

(2) Determine the best estimate of the actual spacecraft orbit and furnish trajectory information to the *Pioneer* Project.

Mission time must be displayed in the operational areas. A backup power system must be ready to take over in the event of commercial power failure.

*d. Data flow and processing.* The *Pioneer* mission operations are concerned with real-time, quick-look, and non-real-time telemetry data requirements (refer to Table 8).

*Real-time data.* This data is received in real-time via hardline or radio communication link and then displayed on-line in the user areas as rapidly as operational priorities permit. (Data is classified as real-time if it is received at the SFOF within 5 to 10 min after receipt by the Deep Space Stations.)

*Quick-look data.* This is selected data extracted onsite by the SDS 910 computer and transmitted in realtime to the SFOF upon request by the SFOD. This data is monitored in the *Pioneer* mission support area and simultaneously transmitted to the ARC data processing center and STL.

*Non-real-time data.* This is data received at the SFOF either in the form of magnetic tape recordings or of

Table 8. Data requirements

| Function | Real-time | Non-real-time |
|---|---|---|
| Data demodulation[a] | X | |
| Data decommutation[a] | X | |
| A to D conversion | | |
| Data formatting[a] | X | |
| Data logging | X | |
| Engineering units conversion[b] | X | |
| Alarm monitoring[b] | X | |
| Orbit determination | | X |
| Trajectory computation | | X |
| Spacecraft orientation[c] | X | |
| Command generation[d] | X | |
| Command verification[a] | X | |
| Scientific data calibration | X | |
| Engineering data analysis[b] | X | X |
| Scientific data analysis[b] | X | X |
| Premission tests and training | X | X |
| Tape dubbing at ARC | | X |

[a]To be done at Deep Space Station sites

[b]Selected data

[c]To be done at Goldstone.

[d]To be initiated at the SFOF but generated at Deep Space Station sites.

delayed transmission from a communications link more than 30 min after receipt of data at the Deep Space Station.

The flow from the SFOF comprises acquisition and tracking information and commands for the Deep Space Stations, general status information, and spacecraft performance data. All Deep Space Station flight data is forwarded within 48 h to SFOF document control at JPL.

The incoming data circuits are routed through the communications center to the teletype machines and closed-circuit TV in the user areas.

N70-28133

## III. *Pioneer VII* TDS Configuration

It was the responsibility of the TDS to properly prepare and configure for the *Pioneer VII* flight. Such configuration was necessary to meet the requirements outlined in Section II.

### A. Near-Earth Phase Configuration

For near-earth support, the TDS was composed of selected resources of the AFETR, MSFN, NASCOM, and DSN (Table 9). Based on trajectory data and requirements, the TDS agencies selected the appropriate metric and telemetry data acquisition instrumentation from resources available at the sites listed in Table 9. Particular attention was given to class I intervals to assure a high probability of providing the required coverage.

*1. Metric data.* AFETR is the primary agency responsible for meeting metric requirements during the launch and earth-orbital mission phases. The addition of MSFN radar instrumentation to that of the AFETR provides the required coverage with a reasonable degree of redundancy. Radars track the *Agena* C-band beacon in meeting both launch vehicle and spacecraft metric requirements. In addition, AFETR optical tracking instruments provide the most accurate source of metric data from liftoff to 5000-ft altitude.

Table 9. TDS near-earth phase facilities

| Agency | Station/location |
|---|---|
| AFETR | Cape Kennedy, Patrick AFB, Fla.<br>Grand Bahama Island<br>Grand Turk Island<br>Antigua Island<br>Ascension Island<br>Pretoria, S. Africa<br>Range Instrumentation Ship *Twin Falls*, South Atlantic<br>Range Instrumentation Ship *Coastal Crusader*, South Atlantic |
| MSFN | Bermuda Island<br>Ascension Island<br>Tananarive, Malagasy<br>Carnarvon, Australia<br>Goddard Space Flight Center, Md.<br>Guam<br>Hawaii |
| NASCOM | Worldwide facilities of NASCOM provided communications between supporting agencies |
| JPL/AFETR | Building AO at Cape Kennedy, Fla. |
| DSN | DSS 71: Cape Kennedy, Fla.<br>DSS 72: Ascension Island<br>DSS 51: Johannesburg, S. Africa<br>SFOF: Pasadena, Calif. |

Figure 11 illustrates the configuration of the metric system and data flow which supports the early launch phase. Optical instruments as well as C-band radars are shown. Figure 12 illustrates the metric configuration for supporting the near-earth orbital phase. The AFETR and MSFN C-band radars are shown, and the flow of data and its format are described.

*2. Telemetry.* The first- and second-stage vehicle was to radiate one PDM/FM/FM telemetry link. Frequency of the first-stage link was 228.2 mHz ±125 kHz. Frequency of the second-stage link will be 234.0 mHz ±125 kHz. The subcarrier configuration of each link was as follows:

| | |
|---|---|
| 400 Hz | Continuous |
| 2.3 kHz | Continuous, link 228.2 only |
| 3.0 kHz | Continuous, link 228.2 only |
| 3.9 kHz | Continuous |
| 5.4 kHz | Continuous |
| 7.35 kHz | Continuous |
| 10.5 kHz | Continuous |
| 14.5 kHz | Continuous |
| 22 kHz | ±15% continuous |
| 40 kHz | ±15% continuous |
| 70 kHz | ±15% commutated 45 × 20 PDM |

*3. Real Time Computer System.* The AFETR RTCS at Cape Kennedy, using CDC 3600 and 3100 computers, processes metric data received from the AFETR and MSFN sites. An important function is the computation and transmission of acquisition information to the various TDS sites supporting the near-earth phase. The flow of acquisition information in the form of interrange vectors and DSN predicts is illustrated in Fig. 12.

Also, the RTCS uses metric data for orbital computations and planetary mapping in meeting trajectory definition requirements. Various computer runs are made, based on actual parking orbit conditions, nominal transfer orbit conditions, actual transfer orbit conditions, and actual postposigrade conditions.

The RTCS retransmits octal teletype data from all radars to GSFC. The RTCS converts AFETR radar teletype data to decimal format and transmits it to the JPL operations center in Building AO, at Cape Kennedy, via 100-word/min teletype circuits. The RTCS also receives high-density data from Bermuda and Carnarvon radars, converts it to decimal format, and transmits it to Building AO. The JPL personnel at Building AO select appropriate metric data and retransmit it to the SFOF via teletype as needed to meet stated requirements.

*4. JPL/AFETR facilities.* The facilities of the field station utilized in support of the mission are the JPL/AFETR operations center and the JPL/AFETR communication center, both in Building AO. These facilities, and the equipment therein, are described in this section. DSS 71 at Cape Kennedy was used extensively and participated in the prelaunch, launch, and near-earth phase operations of the *Pioneer* Project.

*a. JPL/AFETR operations center.* Control of JPL/AFETR operations during the launch phase is exercised from the JPL/AFETR operations center. The operations center contains status displays which indicate the current status of all participating elements of the operation, a timing system, and consoles for the operating personnel. These are described in the following paragraphs.

*Display boards.* There are four display boards in the operations center: the operational status display board, used to indicate current operational status of Cape Kennedy instrumentation sites, the space vehicle, and communication links; the in-flight events display board, used to display the time of significant in-flight events; and the AFETR and DSIF status display boards, used to indicate the status of the participating AFETR and Deep Space Stations.

*Television monitors.* The television monitors are used to display the range safety flight-line and program-line television signals. These are part of a system for monitoring the flight path of the vehicle, both in the plane of the flight azimuth (flight-line) and normal to the plane of the flight azimuth (program-line).

*Optically projected map display.* This display is a map of the world that is projected onto the status board wall. The earth track of the flight azimuth, locations of key in-flight events, and colored circles indicating metric coverage from each tracking station are superimposed on the map.

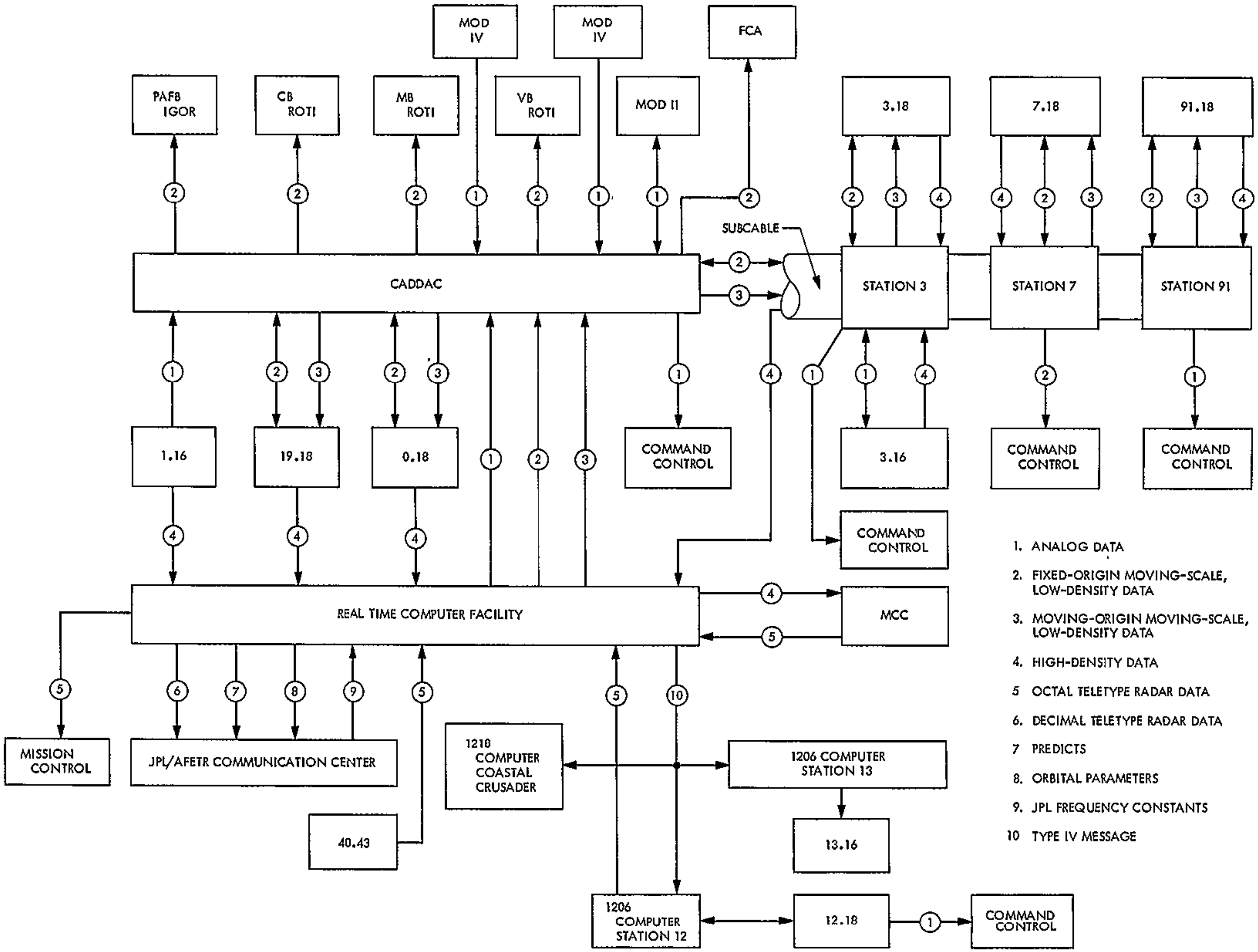


**Fig. 11. Metric data flow, launch phase**

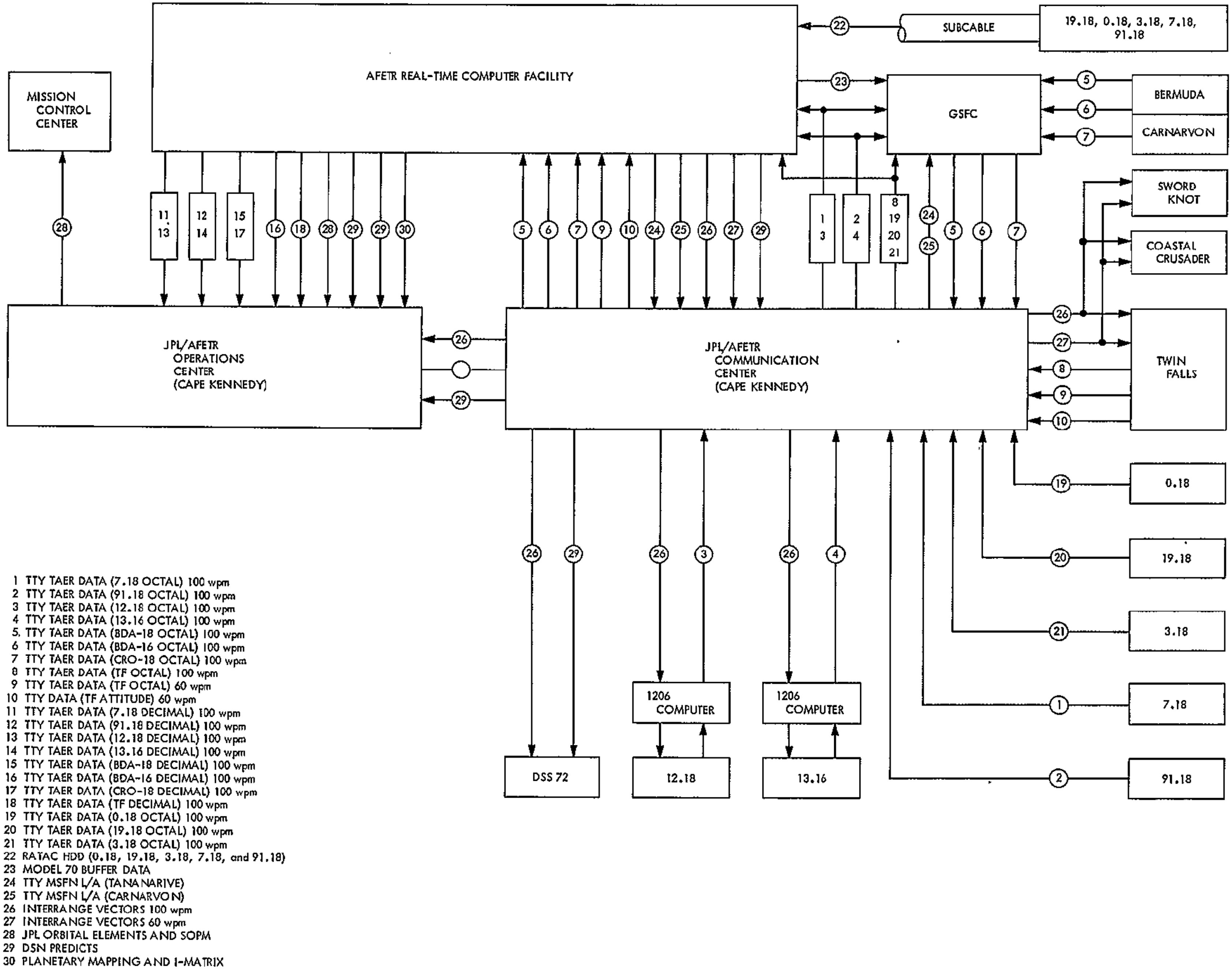


**Fig. 12. Metric data flow, orbital phase**

*Timing system.* An automated timing system is used to display (1) Pacific, Eastern, and Greenwich time; (2) countdown and launch-plus time; (3) anticipated $T$ − zero and actual liftoff time; (4) accumulated hold time at any point in the countdown; and (5) time remaining in the launch window for that day.

*Consoles.* In addition to the integrated communication consoles used by each of the operators, there are two dual television monitor consoles and a status display control console.

Each of the integrated communication consoles contains a green phone switch panel, two MOPS/UCSS panels, and a communication control panel. These are described below:

(1) Green phone switch panel. During operations, the green phone switch panel is used to provide direct point-to-point circuits between major operating facilities (e.g., blockhouse, central control, Cape computer) and the operations center. These circuits are private-line, automatic-signaling circuits used by key personnel. Provisions have been made which allow the green phone system to operate from emergency power. This system, therefore, serves as a backup for the MOPS system.

(2) MOPS/UCSS panels. The MOPS/UCSS panels provide party line communication for operational testing. The two UCSS panels combined provide the capability of monitoring 24 channels. These channels are the prime communication links for the conduct of launch operations.

(3) Communication control panel. Access to two cross-country voice circuits from the SFOF at JPL/Pasadena is provided by the communication control panel. This panel is also used to answer administration telephone calls and can be connected to the green phone switch panel and the MOPS/UCSS panels.

Each of the dual television monitor consoles contains a dual 8-in. television monitor used to view the page printers for two of the outgoing teletype circuits to the SFOF.

The status display control console contains a range countdown indicator and control panels for the timing system and the status display boards.

*b. JPL/AFETR communication center.* The JPL/AFETR communication center contains the necessary equipment to provide (1) a local terminus, and interfaces where required, for voice, teletype, and data circuits from both the SFOF in Pasadena and the AFETR and local Project elements, and (2) local voice, teletype, and data circuits in support of prelaunch tests and launch operations.

*Voice circuits.* The communication center has the capability of terminating up to 50 voice channels from various Cape Kennedy locations; any 24 of these can be patched into the MOPS/UCSS system in the operations center. To provide direct voice circuits to the SFOF in Pasadena, two Bell System leased lines (NASCOM) are terminated in two four-wire bridges. Special telephone panels, which allow certain administrative phones to be switched into the four-wire bridge, provide a backup for the two leased lines.

*Teletype circuits.* Six full-duplex, 60-words/min NASCOM teletype circuits from the SFOF are terminated in the communication center; three of these are routed on a "normal-through" basis to DSS 71. A local circuit from DSS 71 to the communication center is also provided. Nine incoming circuits from AFETR are terminated in the communication center. These may be patched into six typing reperforators, which are operated taut-tape to six transmitter-distributors. These, in turn, can be patched to any of the outgoing circuits to Pasadena. Three additional local circuits, two from Building AM and one from Building AE, are terminated in the communication center. These may be patched to any of the SFOF, AFETR, or DSS 71 lines.

*Data circuits.* A NASCOM data line is routed between the SFOF and the JPL/AFETR communication center. This line is terminated in a patch panel in the communication center which allows either digital or analog data to be patched in. The data line also provides an alternate capability for voice use.

*Teletype circuits.* Metric tracking data, injection conditions and orbital elements, Deep Space Station acquisition information, and other operational messages are received at the JPL/AFETR communication center on nine, half-duplex, 100-words/min teletype circuits from the AFETR RTCF (Fig. 13). This data is retransmitted to the SFOF on three, full-duplex, 60-words/min circuits. An additional three, full-duplex, 60-words/min circuits, from the SFOF to DSS 71, are used for DSIF

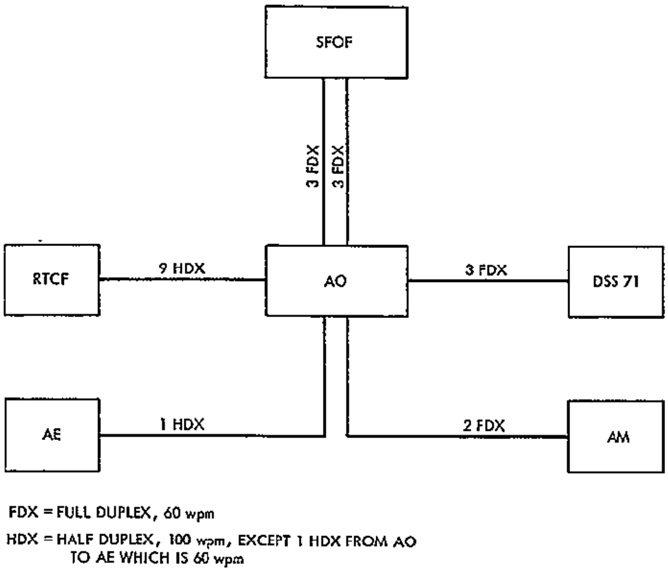


**Fig. 13. Near-earth phase teletype circuits**

operational traffic. One half-duplex, 60-words/min circuit is used to relay RTCF orbital elements from the JPL/AFETR communication center to the mission control center in Building AE, and two, full-duplex, 60-words/min circuits are used for transmitting spacecraft information to Building AM from DSS 71 during the countdown and from DSS 51 during flight.

*c. JPL/AFETR operational support.* The JPL/AFETR field station supported the launch phase operations of *Pioneer VII* by providing the necessary operational interface between project elements at the SFOF in Pasadena and the AFETR and project elements at AFETR. This operational interface comprises the following activities:

(1) Monitoring, and keeping project personnel in the SFOF informed of, the status of AFETR stations, ships, and equipment, launch vehicle and spacecraft, progress through the countdown, and the occurrence and time of in-flight events.

(2) Receiving, and keeping Project personnel at Cape Kennedy informed of, reports on the status of SFOF and DSN stations and equipment and their readiness to support the mission.

(3) Providing liaison between the FPAC group and the AFETR RTCS, through the JPL data coordinator stationed at the RTCS.

(4) Receiving, and retransmitting to the SFOF, AFETR metric tracking data and computed data, including injection conditions, orbital elements, and DSS acquisition information.

(5) Receiving, and retransmitting to Building AE, RTCS orbital information.

(6) Receiving from the SFOF, and retransmitting to the RTCS, Deep Space Station tracking data for use in RTCS orbital computations.

(7) Relaying spacecraft telemetry data from DSS 71 to the SFOF and to Building AM.

(8) Receiving from the SFOF, and retransmitting to Building AM, spacecraft telemetry data from DSS 51.

Personnel responsibilities are as follows:

(1) The operations center coordinator exercises control of JPL/AFETR operations during the launch operations. He supervises the overall activities within the operations center and acts as net controller for the operations center net and the AFETR stations of the crosscountry AFETR net. He coordinates with the supervisor of range operations the prelaunch and in-flight flow of tracking data from the RTCS and Cape communications control to Building AO.

(2) The status coordinator acts in the capacity of assistant operations center coordinator and as net controller for the status coordinator net (internal operations center net) and the AFETR stations of the crosscountry status net. He receives and disseminates status information from the SFOF in Pasadena and from the AFETR and local project elements and insures that all status displays are current and correct.

(3) The status display operator monitors appropriate communications nets for status reports and operates the display boards which indicate the status of the different elements of the mission. In addition, he operates the control panel for the operations center timing system.

(4) The communication center coordinator supervises the data handling and transmission activities within the center and coordinates, with the operations center and the SFOF communication center, the overall operation of the communication center in support of the mission.

(5) The equipment room and message center operators operate the data handling and transmission equipment within the communication center. They perform the necessary patching of voice, teletype, and data circuits to establish the proper circuit configurations for the mission.

(6) The JPL DSN representative monitors DSN activities and acts as local advisor to the mission director and operations center personnel on DSN matters.

(7) The JPL data coordinator coordinates, with the FPAC group, the RTCS operations in the area of computation of orbital and Deep Space Station acquisition information and the reformatting and transmission of metric tracking data.

(8) The JPL project representative performs a liaison function between the superintendent of range operations and the JPL/AFETR operations center. He monitors the overall operation and will, upon request of the supervisor of range operations, advise him on DSN support matters.

*d. JPL/AFETR data transmission.* This subsection identifies the following key communication nets and channel assignments and specifies proper usage and procedures for each:

(1) Mission Operations Intercommunication System. This system, which provides "party-line" communication, is the primary communication system for the conduct of launch operations.

(2) Green phone system. This backup system provides direct, point-to-point communication circuits between major operating facilities (e.g., blockhouse, Cape computer, operations center). These circuits are private-line, automatic-signaling circuits used by key personnel. Provisions have been made which allow the green phone system to operate from emergency power. Operational usage of the green phone nets available in the JPL/AFETR operations center during the *Pioneer VII* launch phase operations is specified in Table 10.

(3) Cross-country voice circuits. Three NASCOM voice circuits between JPL/AFETR and the SFOF are used for voice communication in support of the launch operations. Switching and control of stations that have access to these nets are maintained at both terminals. Operational usage of these nets is defined as follows:

**Table 10. Operational usage of JPL green phone nets**

| Net | Operational usage |
|---|---|
| Between operations center and: | |
| Supervisor of range operations | Communication relative to range readiness for space flight operations support |
| RTCS | Communication relative to real-time tracking and orbital calculations |
| Mission director's center (Bldg. AE) | Coordination |
| DSS 71 | Coordination |
| Project representative at central control | Communication |

Status net. This net is used (1) to keep various SFOF stations informed as to the operational status of the AFETR stations, the launch vehicle, and the spacecraft, mission readiness to launch, progress through the countdown, and the occurrence and time of in-flight events, and (2) to keep the mission director and project elements at AFETR informed as to the status of the various stations of the DSN and their readiness to support the postlaunch operations. Stations normally active on this net are the JPL status coordinator at AFETR and "prime one" at the SFOF.

AFETR net. This net is used for detailed discussions pertaining to the condition and flow of both metric tracking and computed data from AFETR to the SFOF. Stations normally active on this net at AFETR are the JPL data coordinator at the RTCS, the operations center coordinator, and the mission and flight analysts. The mission director and other project officials in the mission director's center have monitoring capability and access to both the status and the AFETR nets as required.

Spacecraft net. This net is used by *Pioneer* personnel in the mission director's center and the SFOF for detailed discussions of spacecraft performance and status. The SFOD reports DSN and SFOF readiness to the mission director on this net.

(4) Metric tracking and computer data. The AFETR radars at Grand Turk, Antigua, and Ascension provide real-time metric tracking data to JPL at Building AO for relay to the SFOF. In addition to

relaying the real-time metric data to JPL, the AFETR RTCS uses this data to compute orbital elements and injection conditions (for the parking orbit and theoretical transfer orbit) which are transmitted to JPL in the following formats: (a) the standard JPL orbital message format, (b) the AFETR interrange vector, and (c) the AFETR standard orbital parameter message. DSS acquisition information for DSS 72, 51, and 42 is prepared by the RTCS and forwarded to JPL. In addition, AFETR transmits interrange vector messages and DSS 72 predicts directly to DSS 71. Following the single-station solutions, the RTCS computes and transmits to JPL recursive accumulative orbits. An I-matrix based on each solution is included.

## B. Deep Space Phase Configuration

The major DSN elements are (1) the DSIF, (2) the SFOF, and (3) the GCF. Figures 14, 15, and 16 give the generalized data flow for *Pioneer* tracking, telemetry, and reloaded data within the DSN.

*1. Deep Space Instrumentation Facility.* The function of the DSIF was to obtain angular position, doppler, and telemetry data from the *Pioneer* spacecraft during the postinjection phase of the mission. Data obtained by the DSIF was transmitted to the SFOF in real-time by teletype circuits. In addition, the same data was recorded on magnetic tape at each Deep Space Station and dispatched to JPL by air service.

The Deep Space Stations designated as primary to the DSIF in support of *Pioneer VII* were DSS 12, 42, 51, and 71. The locations of these stations are given in Table 2. The parameters and capabilities of each Deep Space Station are given in Table 11. The operational frequency assignments are listed in Table 12. Compatible telecommunications modes are listed in Table 13. The tracking data format is shown in Table 14. Tracking data was to be in one of four forms, depending on the station configuration and the use of the long form or the short form.. All transmissions were preceded by a descriptor, as shown in Table 14. The ground station tracking modes are listed in Table 15. Block diagrams of the stations are presented in Figs. 17 and 18. Figure 19 depicts the relationship of the Deep Space Stations assigned to the *Pioneer VII* mission to the SFOF within the DSN.

*a. Deep Space Station coverage.* The locations of and the coverage provided by the three selected stations is depicted in Fig. 20.

**Table 11. Deep Space Station capabilities for *Pioneer VII* support**

| Parameters | DSS 12 (GSDS S-band) | DSS 42 (GSDS S-band) | DSS 51 (L-to-S conversion kit) |
|---|---|---|---|
| Receiver capability | Two | Two | One |
| Antenna | 85-ft parabolic | 85-ft parabolic | 85-ft parabolic |
| Mount | Polar (HA-Dec) | Polar (HA-Dec) | Polar (HA-Dec) |
| Maximum angular rate, deg/s (both axes) | 0.7 | 0.7 | 0.7 |
| Antenna gain, dB | | | |
| Receiving | 53.0±1 | 53.0±1 | 53.0±1 |
| Transmitting | 51.0±1 | 51.0±1 | 51.0±1 |
| Antenna bandwidth, deg | 0.4 | 0.4 | 0.4 |
| Typical system temperature, °K | 60 | 60 | 60 |
| Transmitter power, kW | 10 | 10 | 10 |
| Data transmission (TTY) | | | |
| Angles | Real-time | Real-time | Real-time |
| Doppler | Real-time | Real-time | Real-time |
| Telemetry | Real- and near-real-time | Real- and near-real-time | Real- and near-real-time |
| Demodulated telemetry | Dual channel | Dual channel | Single channel |
| Command capability | Yes | Yes | Yes |
| Data pack air shipment time to JPL | 1 day | 6 days | 5 days |

Note Capability difference between L-to-S conversion kit stations and GSDS S-band stations are (1) doppler format and (2) single receiver.

**Table 12. Operational frequency assignments**

| Channel | Receive, MHz |
|---|---|
| 6A | 2292.037037 |
| 7A | 2292.407407 |
| | Transmit, MHz |
| 6B | 2110.584105 |
| 7B | 2110.925154 |

*b. Backup stations.* Backup stations (DSS 11, 41, and 61) were available for emergency recording of the telemetry subcarrier on magnetic tape wherever possible throughout the mission.

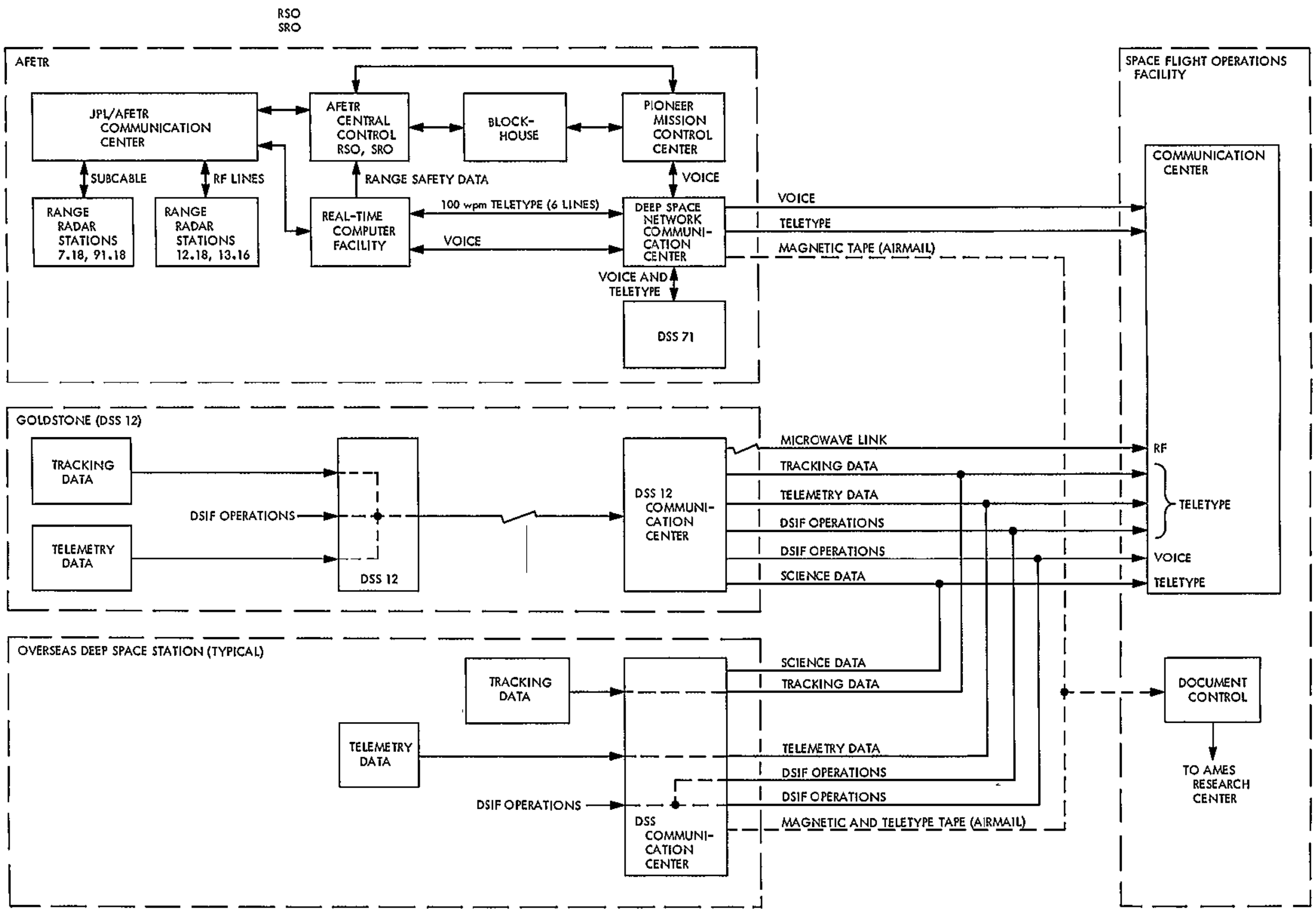


**Fig. 14. Telemetry and metric data flow from AFETR and the DSIF to the SFOF**

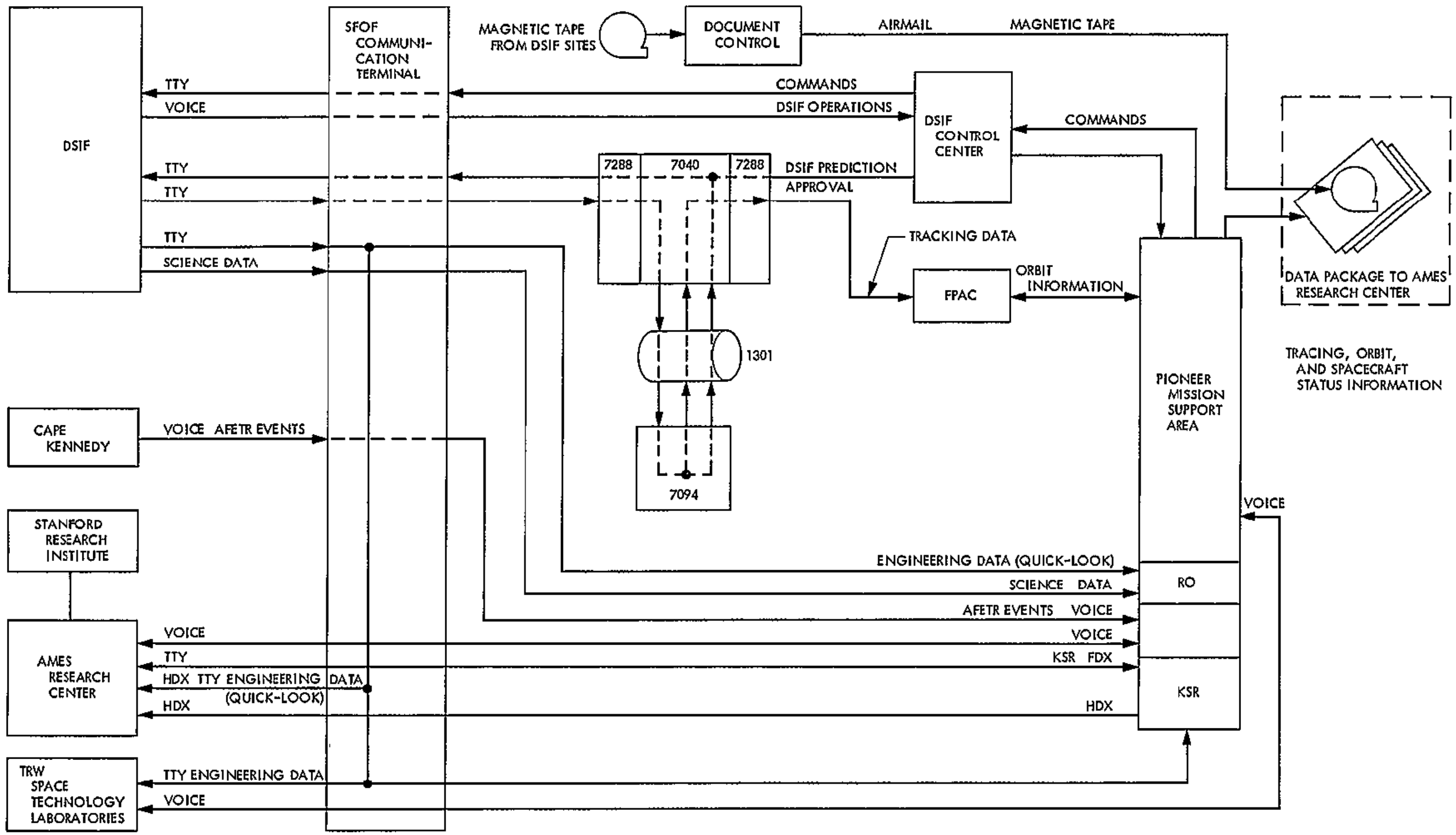


**Fig. 15. *Pioneer* SFOF data flow**

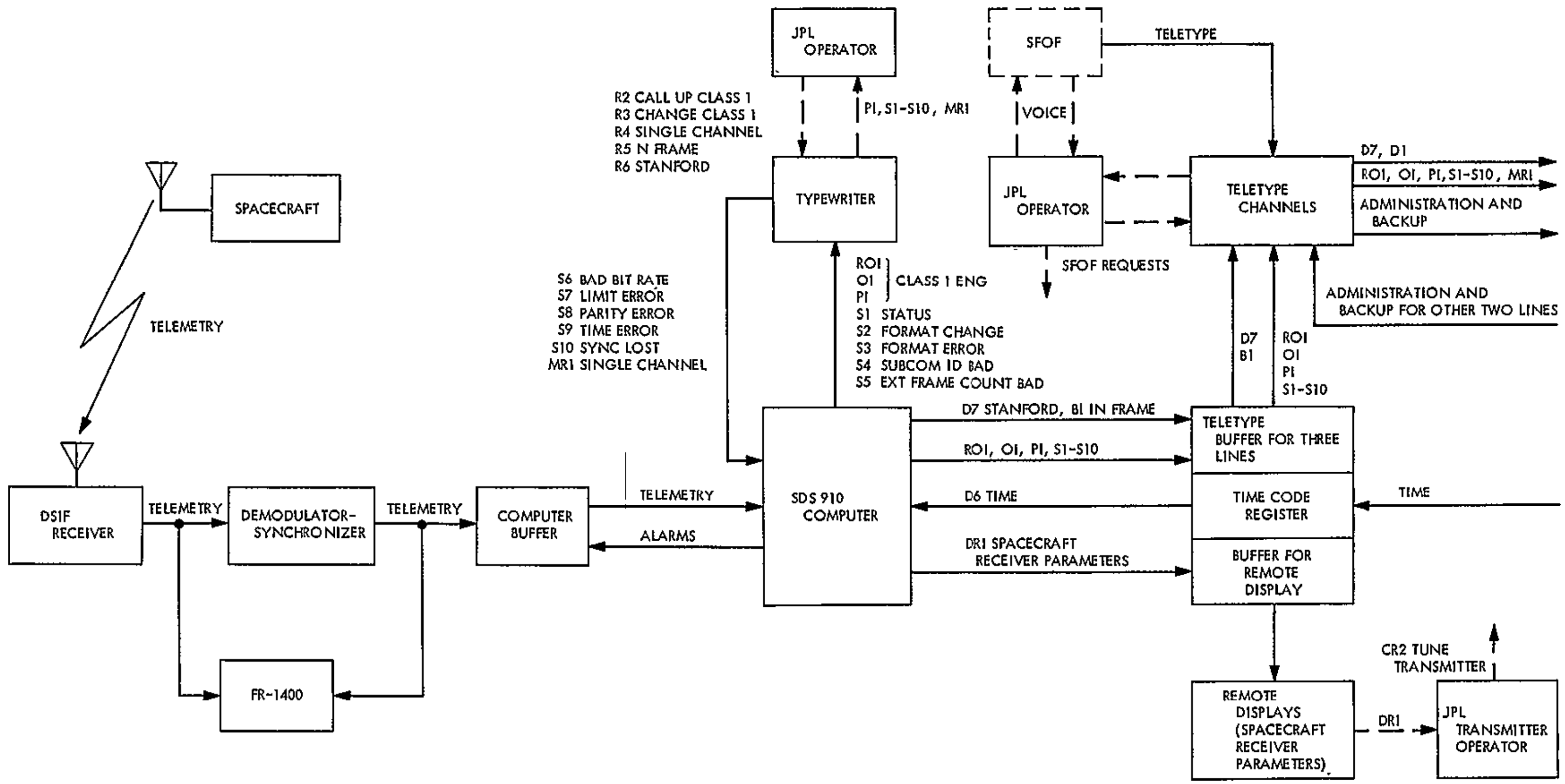


**Fig. 16.** ***Pioneer*** **telemetry data flow and associated functions**

Table 13. Compatible telecommunication modes

| Mode | One-way doppler | Two-way doppler | Two-way noncoherent doppler | Angle tracking | Ranging | Command | Telemetering |
|---|---|---|---|---|---|---|---|
| One-way doppler | | | | X | | | X |
| Two-way doppler | | | | X | X | X | X |
| Two-way noncoherent doppler | | | | X[a] | | X | X[a] |
| Angle tracking | X | X | X[a] | | X | X | X |
| Ranging | | X | | X | | | X |
| Command | | X | | X | | | X |
| Telemetering | X | X | X[a] | X | X | X | |

[a]Only at receiving station.

Table 14. Deep Space Station tracking data format

| DESCRIPTOR | C/R | L/F | F | XX | S | XX | S | XX | S | XXXX | S | XXXXXX | S | XXX | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | STA ID | | | FORMAT ID | | S/C ID | | DATA CONDITION | | GMT | | DAY | |

| | | | | | |
|---|---|---|---|---|---|
| S-BAND LONG FORM FORMAT ID = 02 | DESCRIPTOR | XXXXXXXXXX S DOPPLER | XXXXXXXXXXX S RANGE AND RANGE DC | XXXXXX S LHA | XXXXXX DEC |
| S-BAND SHORT FORM FORMAT ID = 03 | DESCRIPTOR | XXXXXXXXXX S DOPPLER | XXXXXXXXXXX RANGE AND RANGE DC | | |

LHA = local hour angle; DEC = declination, SYN = synthesizer (last 5 digits).

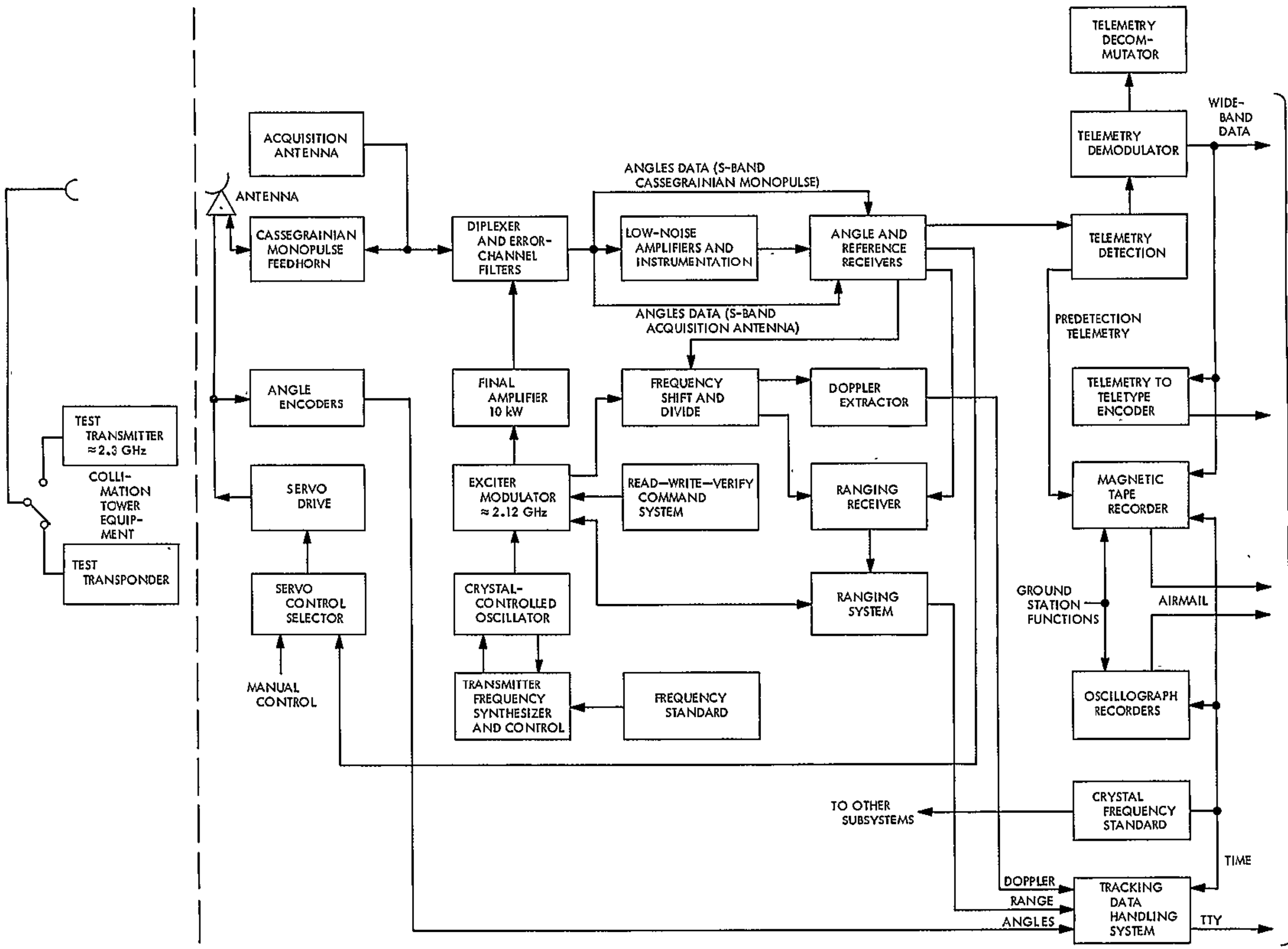


Fig. 17. *Pioneer VII* typical Deep Space Station S-band configuration

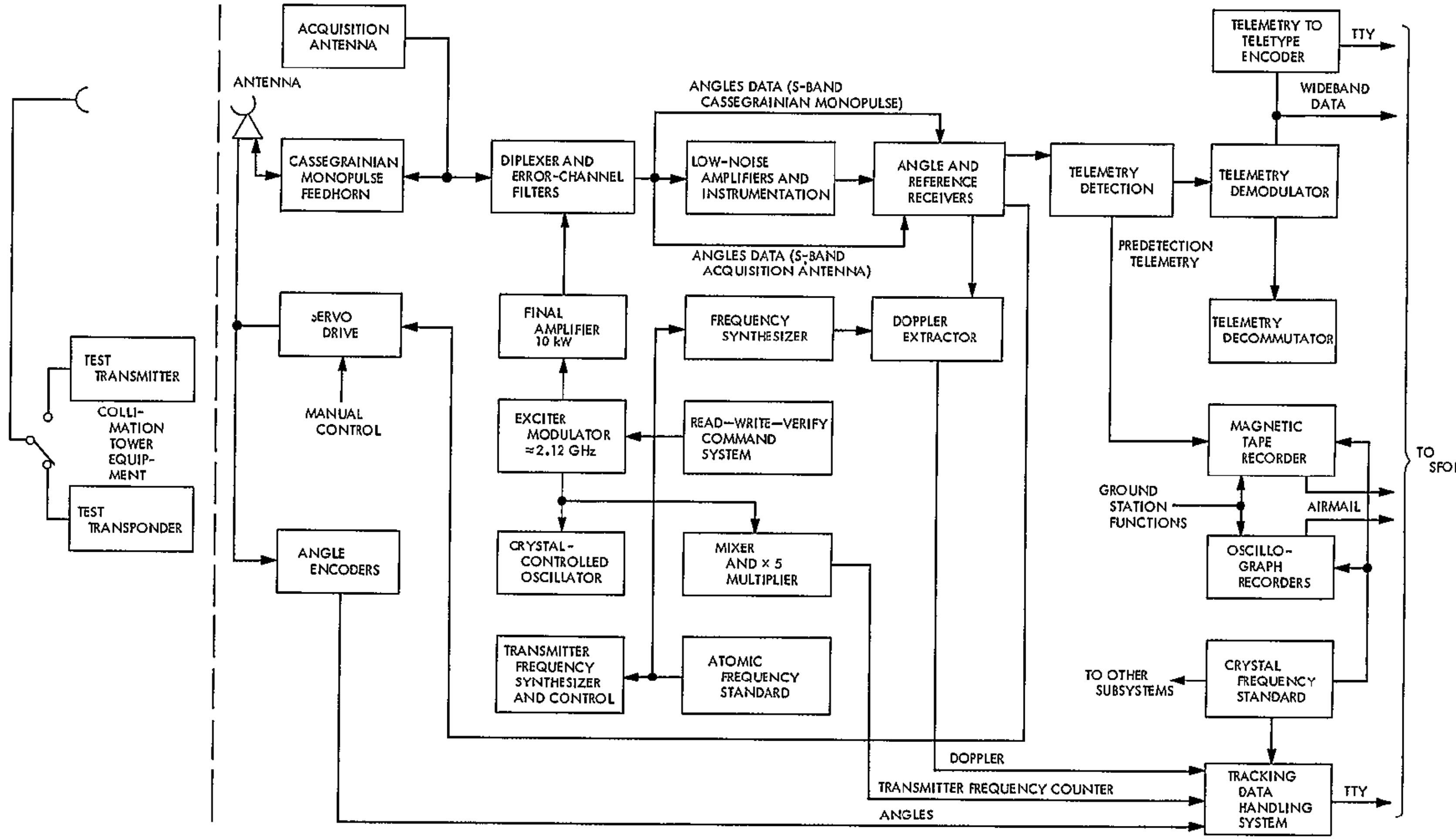


**Fig. 18.** ***Pioneer VII*** **typical Deep Space Station L- and S-band conversion**

**Table 15. Ground station tracking modes**

| Transmit/receive[a, b] (GM = ground mode) | | Feed | |
|---|---|---|---|
| GM-0 | No receive (transmit only) | 0 | Not used |
| GM-1 | One-way doppler (receive only) | 1 | Horn feed/diplexer combination (85-ft reflector) |
| GM-2 | Two-way, one-station (transmit/receive) | 2 | Tracking feed/diplexer combination (85-ft reflector) |
| GM-3 | Two-way; two-station noncoherent (receive only) | 3 | Acquisition antenna |
| GM-4 | Two-way, two-station coherent (receive only with reference signal from transmit station) | 4 | Dipole (6-ft reflector) |
| GM-5 | Receive only (no doppler) | 5 | Horn feed, no diplexer (receive only) (85-ft reflector) |

[a]Example: GM-2-1: transmitting to spacecraft and receiving two-way doppler; horn feed and diplexer.

[b]Telemetry available in all receive modes except GM-0

c. *Mission-dependent equipment.* A significant amount of special-purpose and mission-dependent equipment and many facilities were provided by the *Pioneer* Project for accomplishing the mission objectives. The spacecraft and scientific instruments are easily recognized as belonging to this group. In addition, however, electrical ground support equipment was provided for checking out the spacecraft and, to a lesser extent, the scientific instruments, and for verifying their launch readiness. Ground operational equipment was supplied to four stations for processing telemetry data and transmitting commands to the spacecraft. Equipment was specially designed and fabricated for decommutating and processing telemetry data recorded on magnetic tapes. General-purpose equipment was installed at ARC and the SFOF to provide for mission control from these sites.

d. *Ground operational equipment.* The worldwide DSN provided the entire tracking, data acquisition, and command transmission during the free-flight portion of the *Pioneer VII* mission. To permit partial telemetry data processing in real-time and command transmission, three of the Deep Space Stations were supplied with mission-dependent equipment. As shown in Fig. 21, the in-line GOE consists of a command encoder, a computer buffer, and a demodulator/synchronizer. Associated test equipment consisting of a test transponder and an error rate tester was also supplied to each of these stations. In addition, a data format generator was supplied to DSS 12. Display and plotting equipment for use during the type II orientation was also supplied to DSS 12. Figure 22 shows the five racks of GOE supplied to DSS 12; at the other stations only the three racks of GOE on the left but without the data format generator were supplied.

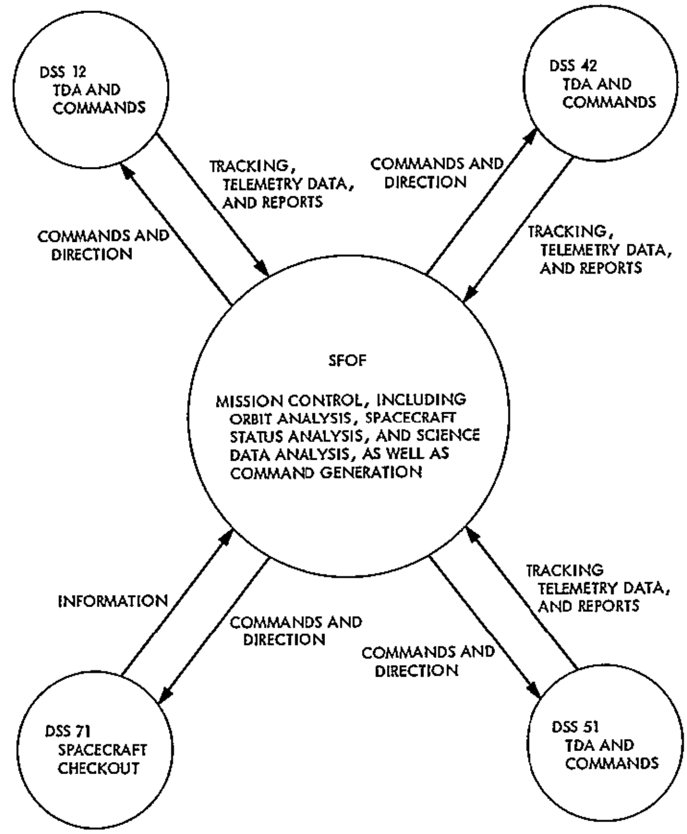


**Fig. 19. Relationship of Deep Space Stations to SFOF within the DSN**

The in-line GOE, in conjunction with the mission-independent equipment shown in Fig. 21, processes the spacecraft telemetry data to provide:

(1) Preselected spacecraft engineering data and up to 2176 words (7 bits long) of consecutive spacecraft telemetry for immediate teletype transmission to the SFOF and ARC.

(2) Continuous evaluation of preselected engineering measurements and generation of alarm signals for teletype transmission to the SFOF and ARC to indicate data processing irregularities or that data is outside preset limits.

(3) Computer typewriter printout of preselected spacecraft engineering data and selectable individual engineering or scientific measurements at each station.

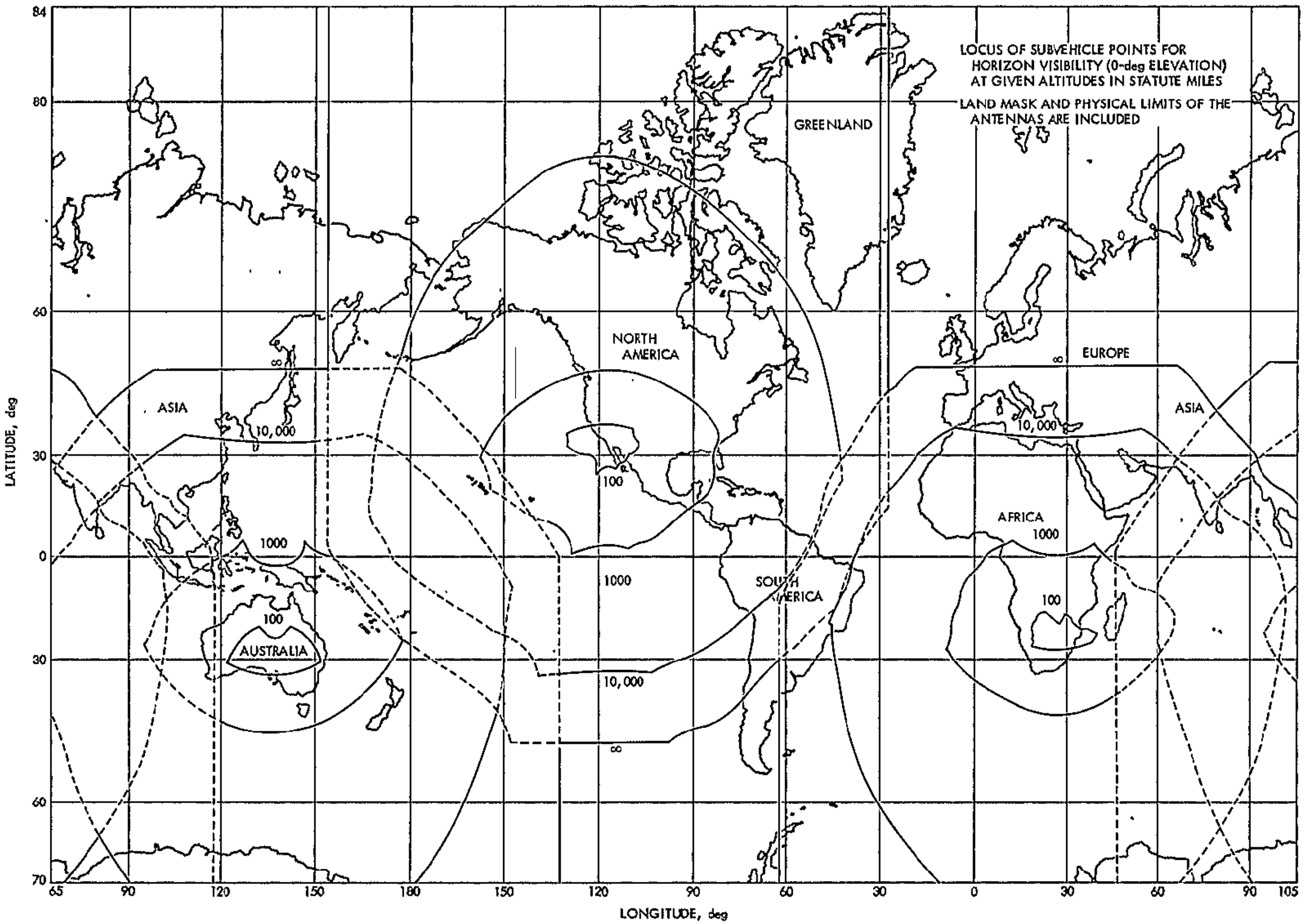


Fig. 20. Deep Space Station location coverage

(4) Displayed values of spacecraft parameters required by station operators to verify up-link acquisition and the quality of spacecraft receiver lock.

(5) Preselected scientific data for immediate teletype transmission to Stanford University.

The capabilities of the system related to command transmission provide:

(1) A command message corresponding to a manually inserted command.

(2) A means for preventing the transmission of any command not contained in a "permissive command list" previously inserted in the computer.

(3) Verification by means of the command monitor receiver and the computer that the transmitted command message corresponds to the manually inserted command and termination of transmission when an error is detected.

(4) Spacecraft command status, notation of the transmitted commands and their time of transmission, and verification, where possible, of command execution on the spacecraft for immediate computer typewriter printout at the Deep Space Station and teletype transmission to the SFOF and ARC.

The system also prepares messages pertaining to the operating status of the GOE and computer and the parity error rate of the processed telemetry data for typewriter printout and teletype transmission. Because of teletype limitations, the system cannot transmit all the telemetry data received at the four highest bit rates. The telemetry data is therefore recorded on magnetic tape, together with command messages, verbal messages by station personnel during a *Pioneer* track, timing signals, and the performance of selected station equipment, for later processing at the *Pioneer* off-line data processing station at ARC.

*Demodulator/synchronizer.* The function of the demodulator/synchronizer is to demodulate simultaneously the *Pioneer* telemetry subcarrier and generate a bit clock pulse train which is synchronous with the data. The input to the demodulator/synchronizer is the bi-phase-modulated 2048-Hz subcarrier from the station receiver during tracking, but it can also be a similar signal from the data format generator, the error rate tester, or the magnetic tape recorder during testing. The output of the unit is a noise-free replica of the data bit stream, a pulse train synchronous with the data, and a sync status signal. For most conditions, operation of the demodulator/synchronizer is fully automatic except for source and bit rate selection.

*Command encoder.* The command encoder produces a 23-s-long command message, corresponding to a manually inserted command, which phase-modulates the station transmitter. The equipment permits visual inspection of the inserted command and operates in combination with the station computer to provide the "permissive command list" check previously mentioned. Switches are provided to override this feature in the event of computer malfunction or to stop command transmission.

*Computer buffer.* The computer buffer serves as a communications link between the mission-dependent equipment and the computer. It accumulates data to be entered into the computer and distributes data from the computer. The buffer provides audible and visual alarms when either bit synchronization or word synchronization is lost and when spacecraft engineering data is out of limits.

*Test equipment.* The test equipment simulates the spacecraft communications in its various modes of operation for use during prepass and postpass checkout of the in-line, mission-dependent and mission-independent equipment. The test equipment also facilitates trouble shooting of the GOE.

The transponder has a receiver (two receivers in the unit for DSS 12), a command decoder (a display in DSS 12 unit), and a transmitter driver which can be suitably modulated and which produces an S-band signal whose strength can be attenuated over a range of 100 dB. The transponder can operate in either a coherent or noncoherent mode. The data format generator produces a simulated spacecraft data bit stream which can either modulate the transponder or be sent directly to the demodulator/synchronizer or to the computer buffer. To evaluate the performance of the demodulator/synchronizer, the error rate tester supplies the demodulator/synchronizer with a bi-phase-modulated, 2048-Hz, square-wave subcarrier of selectable signal-to-noise ratio and known bit sequence and compares the reconstructed data returned by the demodulator with the original bit sequence. The data stream available from the data format generator can be substituted for the bit sequence generated within the tester to simulate a modulated spacecraft telemetry subcarrier of known signal-to-noise ratio.

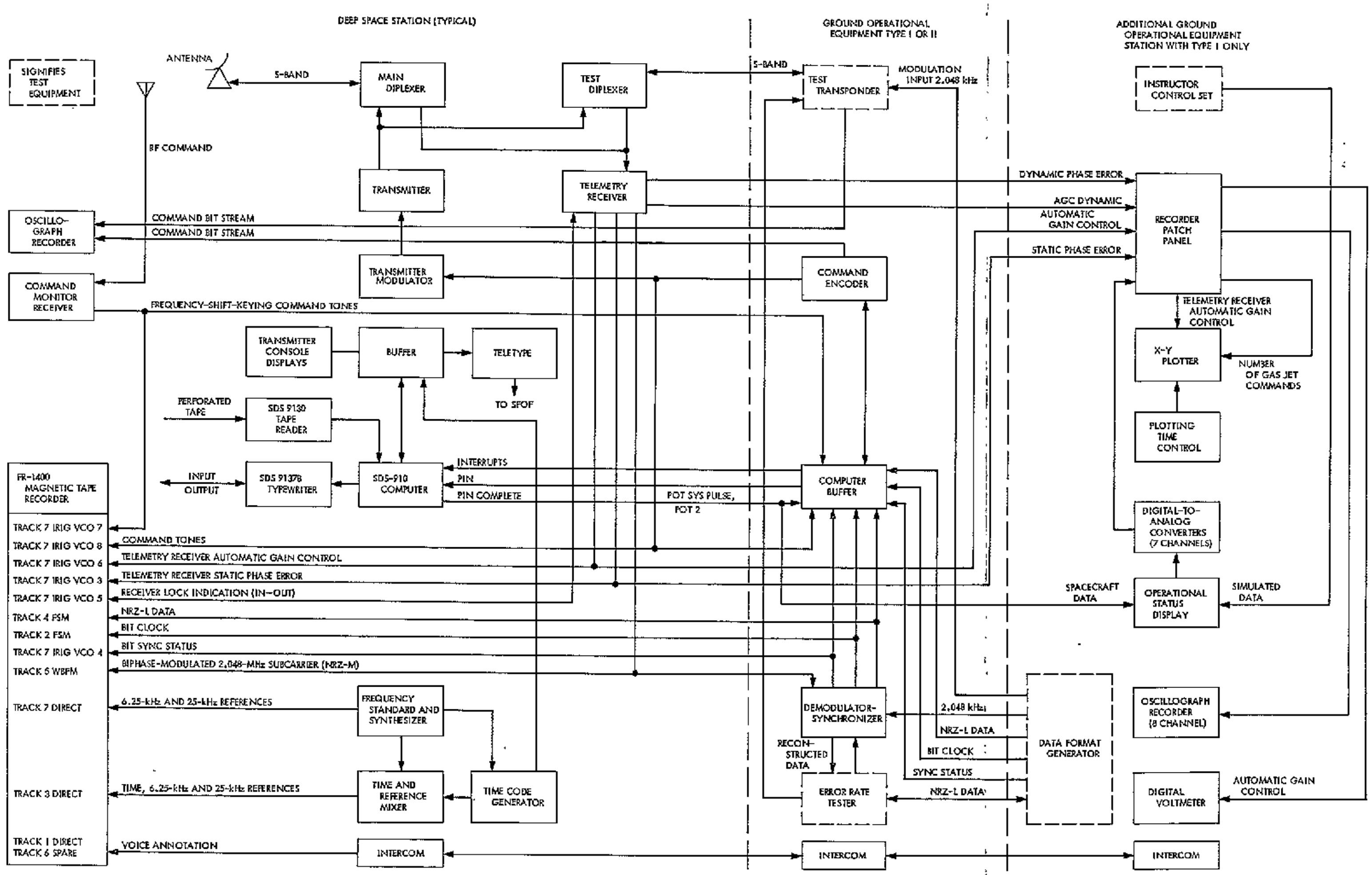


**Fig. 21. Deep Space Station/Pioneer GOE**

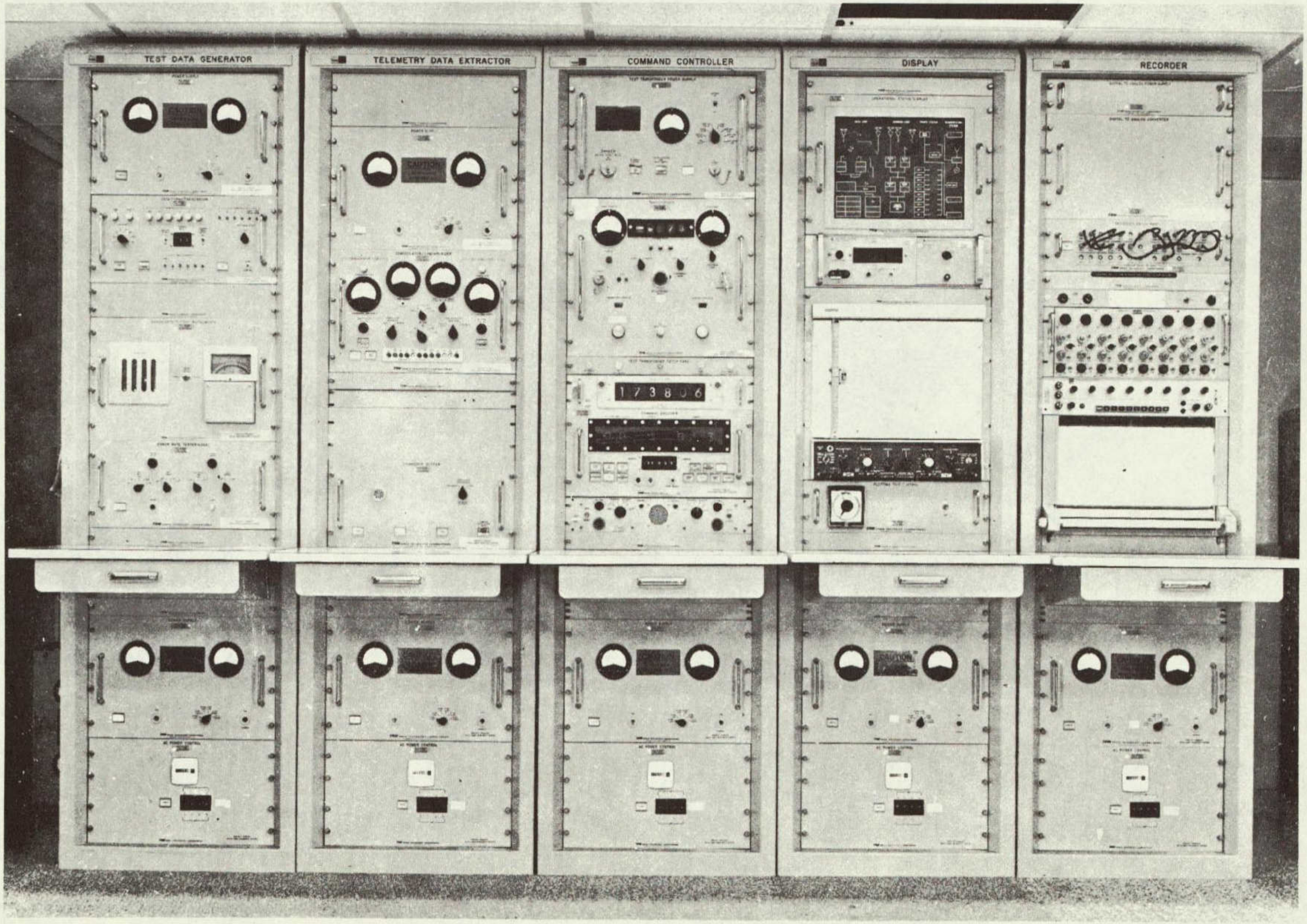


**Fig. 22. *Pioneer* GOE at DSS 12**

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*e. Electrical ground support equipment.* The *Pioneer* electrical ground support equipment was designed and built to support testing performance evaluation of the spacecraft prior to launch; it is the central point for test control and monitoring, command transmission, telemetry acquisition, and spacecraft subsystem simulation, and for the processing, display, and recording of spacecraft and scientific instrument data. The various assemblies comprising the electrical ground support equipment, together with their relationship to the spacecraft, are shown in Fig. 23. Several of these assemblies such as the demodulator/synchronizer, the command encoder, and the computer buffer are similar to those used in the GOE and accomplish the same function. The functions of many of the other assemblies can be essentially inferred from their name.

The electrical ground support equipment (Fig. 24) is composed of a digital computer subsystem and five dolly-mounted consoles: the ground power console, the test console, the recorder console, the radio frequency console, and the telemetry data console. The subsystems perform the following functions:

(1) The digital computer subsystem, which processes, in real-time, spacecraft data received from the demodulator/synchronizer, consists of a digital computer, typewriter, line printer, paper tape reader, and paper tape punch. The subsystem controls the spacecraft status and telemetry data displays and performs a number of computations so that the printout of spacecraft and scientific instrument data is in meaningful measurements and units and in a form suitable for analysis and evaluation.

(2) The ground power console provides and controls power to the spacecraft during tests and monitors the spacecraft bus and battery voltages and currents.

(3) The test console consists of a test point monitor and control and a sun sensor simulator. The test point monitor and control acts as an interface for all hardline signals between the spacecraft and the electrical test equipment exclusive of ground power and rf signals. The sun sensor simulator provides signals to the orientation subsystem, which simulates operation of the five sun sensors. Various spacecraft spin rates can also be simulated.

(4) The recorder console consists of an instrumentation patch panel, a direct-write analog 8-channel strip chart recorder, and an analog magnetic tape recorder. The latter provides the capability for recording signals and playing them back.

(5) The rf console contains the command transmission and data receiving equipment, which consists of a command encoder, command transmitter, ramp generator, antenna, and telemetry receiver. The signal is transmitted through a coaxial cable connected to the spacecraft or via rf radiation. The command encoder differs functionally from that in the GOE in that there is no capability for a "permissive command list" check. The ramp generator provides a means to vary the transmitter carrier frequency in a manner simulating doppler rate.

(6) The telemetry data console consists of a demodulator/synchronizer, computer buffer, data format generator, and display units. These units provide the same functions as those in the GOE.

In addition to the above, a sun sensor simulator is available which can apply appropriate light pulses to the sun sensors to check their operation.

*f. Commands.* The *Pioneer* spacecraft command messages were generated semiautomatically under operator control in the command encoder. The encoder may generate up to 128 unique 23-bit command messages in the format recognized by the spacecraft, including preamble, sync, address, command complement, command, and postsquelch bits. The command and address portions of the messages were generated in a binary-coded octal form and placed in a 10-bit register. The register contents were changed to frequency-shift-keyed tones, which were then sent to the transmitter modulator. A binary one (1) is represented by a 240-Hz sine wave to the modulator, and a binary zero (0) by a 150-Hz sine wave. Figure 25 is a block diagram of the DSIF command signal flow for normal operations.

The basic command philosophy was as follows:

(1) Any command deemed necessary for corrective actions or for achieving a spacecraft mission must be approved by the SFOD. Upon concurrence of the project manager, the commands are transmitted to the Deep Space Station for execution.

(2) Command requests were made only by the technical and operations teams within the SFOF, using approved command decision procedures.

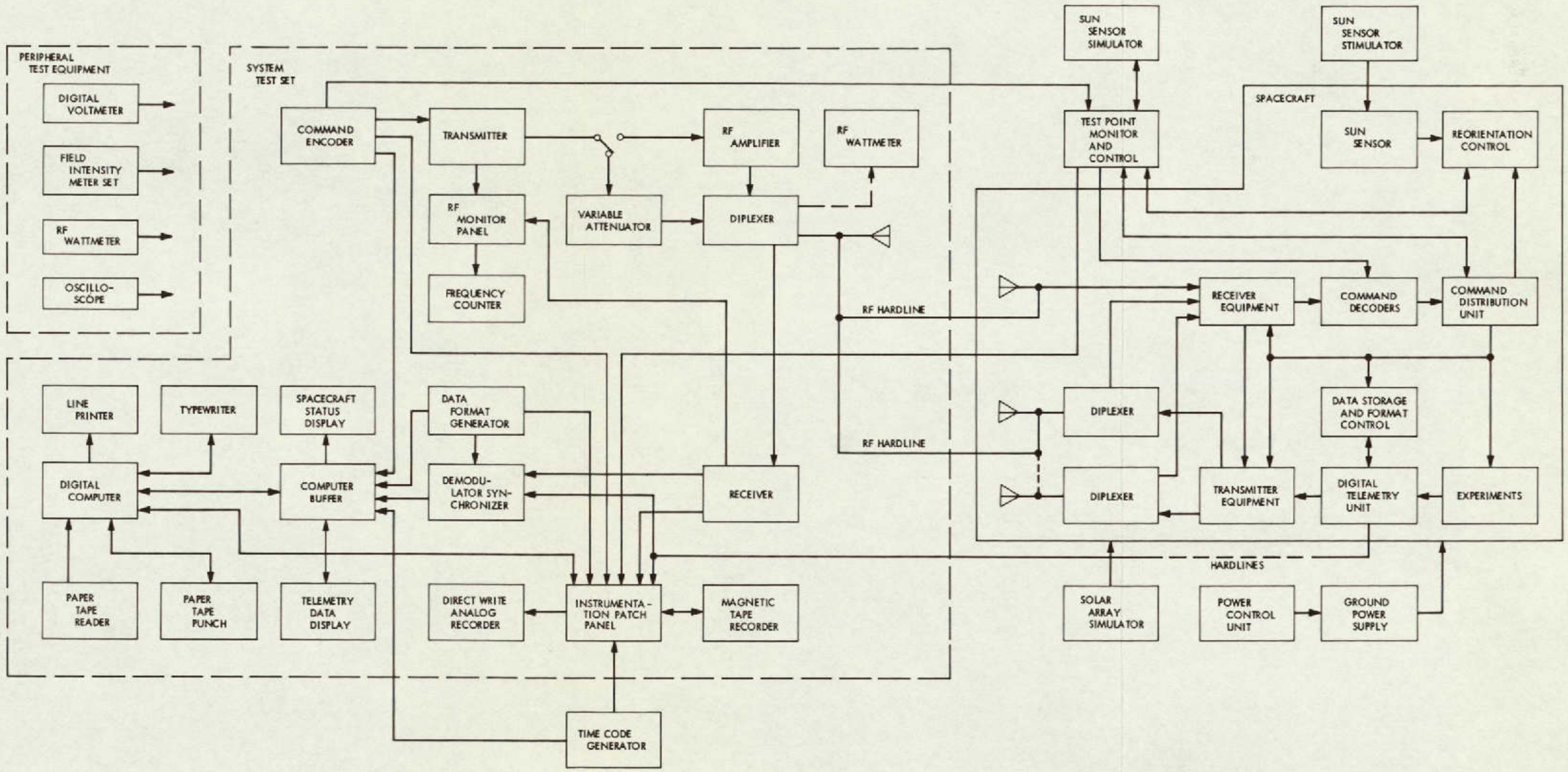


**Fig. 23. EGSE showing relationship to spacecraft**



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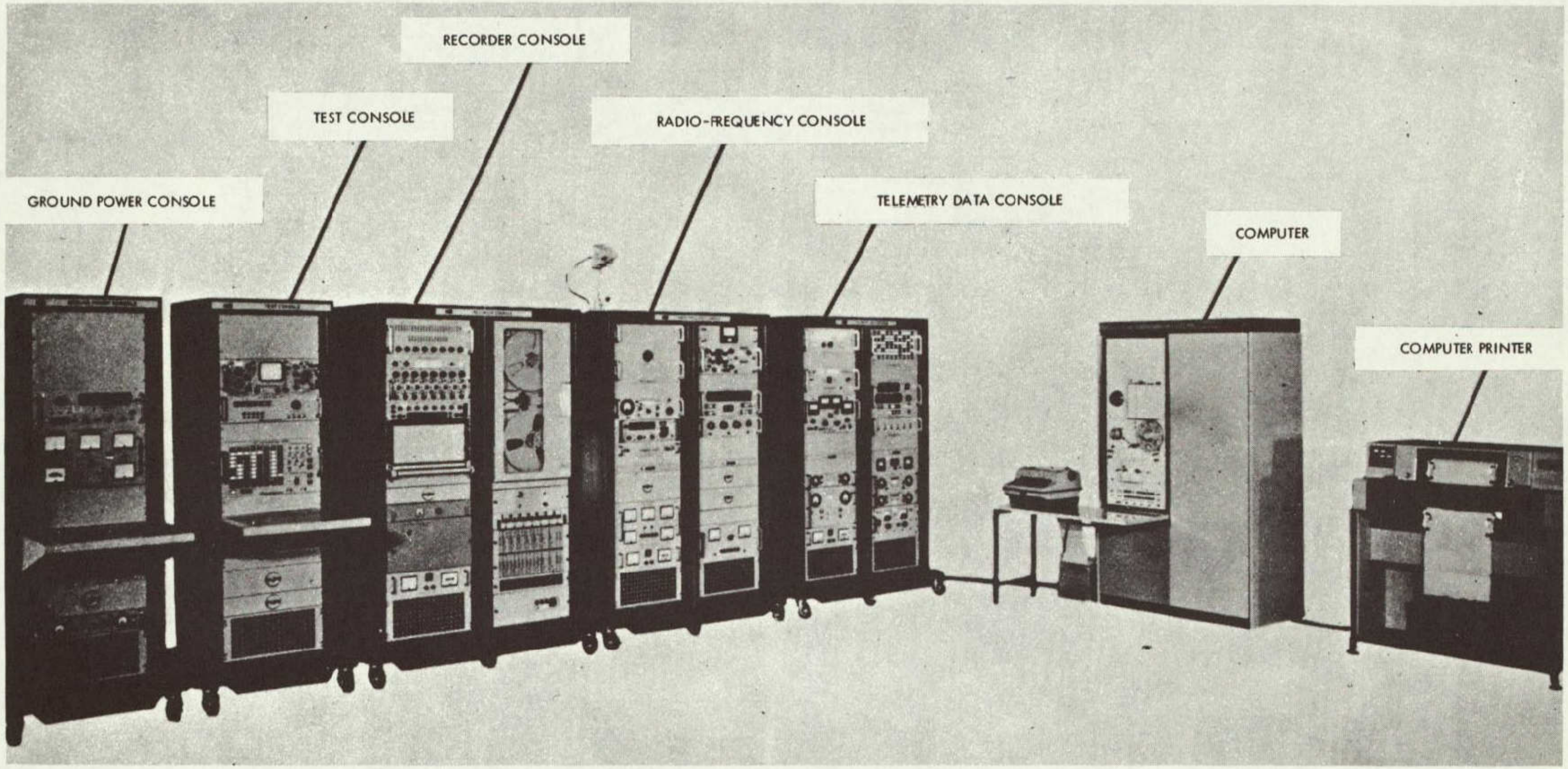



**Fig. 24. EGSE system test station**

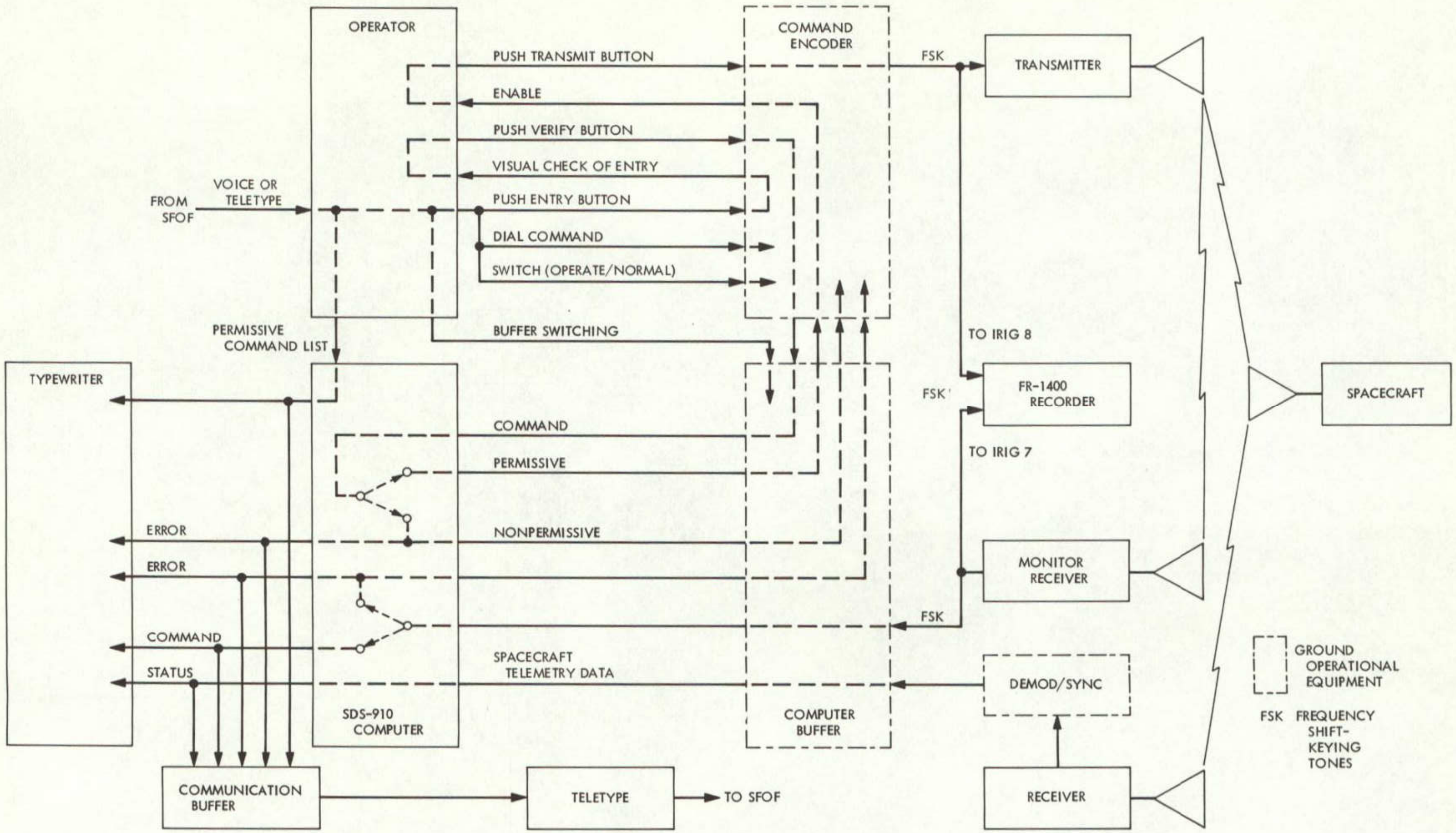



**Fig. 25. Command signal flow for normal operations, DSIF**

(3) Routine command sequences were listed in the daily operations plan for nominal station passes. After approval of the daily operations plan by the project manager, the SFOD was responsible for routine execution of such commands.

(4) All *Pioneer* commands sent in the normal commanding mode were transmitted under computer control and then checked against a permissive command tape loaded into the SDS 910 computer at the beginning of a pass or segment of the operation.

The SDS 910 computer verifies the commands sent to the spacecraft at three different times: (1) pretransmission, (2) during transmission, and (3) posttransmission.

*Pretransmission verification.* At the beginning of each pass, a perforated tape is loaded into the computer that contains the applicable spacecraft command decoder address and all permissible commands for this pass. After the operator has manually selected both the spacecraft decoder address and the command, the computer can be interrogated (by use of a push button on the command encoder which causes a computer interrupt) to verify that the manual selection is indeed permissible for this pass. If it is permissible, a signal is sent to the command encoder to visually indicate this fact. If the manual selection is improper, an appropriate message is typed out.

*During transmission verification.* During transmission of the command, the command generator sends 23 interrupts at 1 bit/s to the computer. At the same time, the outputs of the command monitor receiver are also available as a computer input. On this basis, the computer checks each of the 23 bits as they are serially transmitted. If any of the bits are incorrect, the computer generates an output signal that inhibits any further transmission and types and punches an appropriate message that generates an alarm. If all 23 bits verify properly, a message is both punched and typed indicating that a spacecraft command was sent to the spacecraft at the indicated time. The spacecraft will not react to a partial command message.

*Posttransmission verification.* The posttransmission verification is based on received telemetry signals. If the command that has been sent is verifiable, it is entered into a "command sent" storage list. Then, as changes are detected in the spacecraft status bits from the received telemetry, these changes will be verified against the contents of the "commands sent" list to see that they were indeed commanded. Should any status bits change without having been called for by a command, an appropriate message is typed and punched and an alarm signal generated. Furthermore, the contents of the "commands sent" list, if any, are printed out at the end of each standard printout. Hence, if a command has been sent but not executed, this can be readily seen on the basis of this typed output. (Assuming normal spacecraft operation, all commands are prohibited during the launch phase through the completion of type I orientation. All commands are permitted subsequent to the conclusion of the initial type I maneuver.)

*g. Facilities.*

*DSS 42, Tidbinbilla, Australia.* The DSN was to provide a room approximately 15 ft by 30 ft in the control building for the exclusive use of the *Pioneer* project for the installation of project-peculiar equipment (Fig. 26). Occupancy date was April 1, 1965. Facility support provided for this space was as follows:

Power: 120 Vac ±10%, 60 ±1 Hz, with capacity sufficient for the project-peculiar equipment; 120 Vac, 60-Hz power outlets for auxiliary equipment.

Room temperature: 70 ±5°F.

Plenum air temperature: 55 ±5°F.

Humidity: 50 ±10% relative.

Lighting: 100 ft-cd.

Acoustic level: 65 dB above $10^{-16}$ W/cm$^2$ max.

The DSN was to provide one SDS-910 computer with 8192 words of memory for use by the Project with a degree of reliability comparable to other elements of the DSN. This computer was to remain integral to the digital instrumentation system at each station. The DSN was not to fund or procure any special buffer registers, logic level converters, or special interface equipment for inputting or outputting data to or from this computer.

The DSN was to operate and maintain the project-dependent equipment supplied by the Project.

The DSN was to provide, subject to circuit priorities, two full-duplex teletype circuits between the SFOF and the Tidbinbilla station for full-time use by *Pioneer* during a pass to which the station is assigned and on a shared

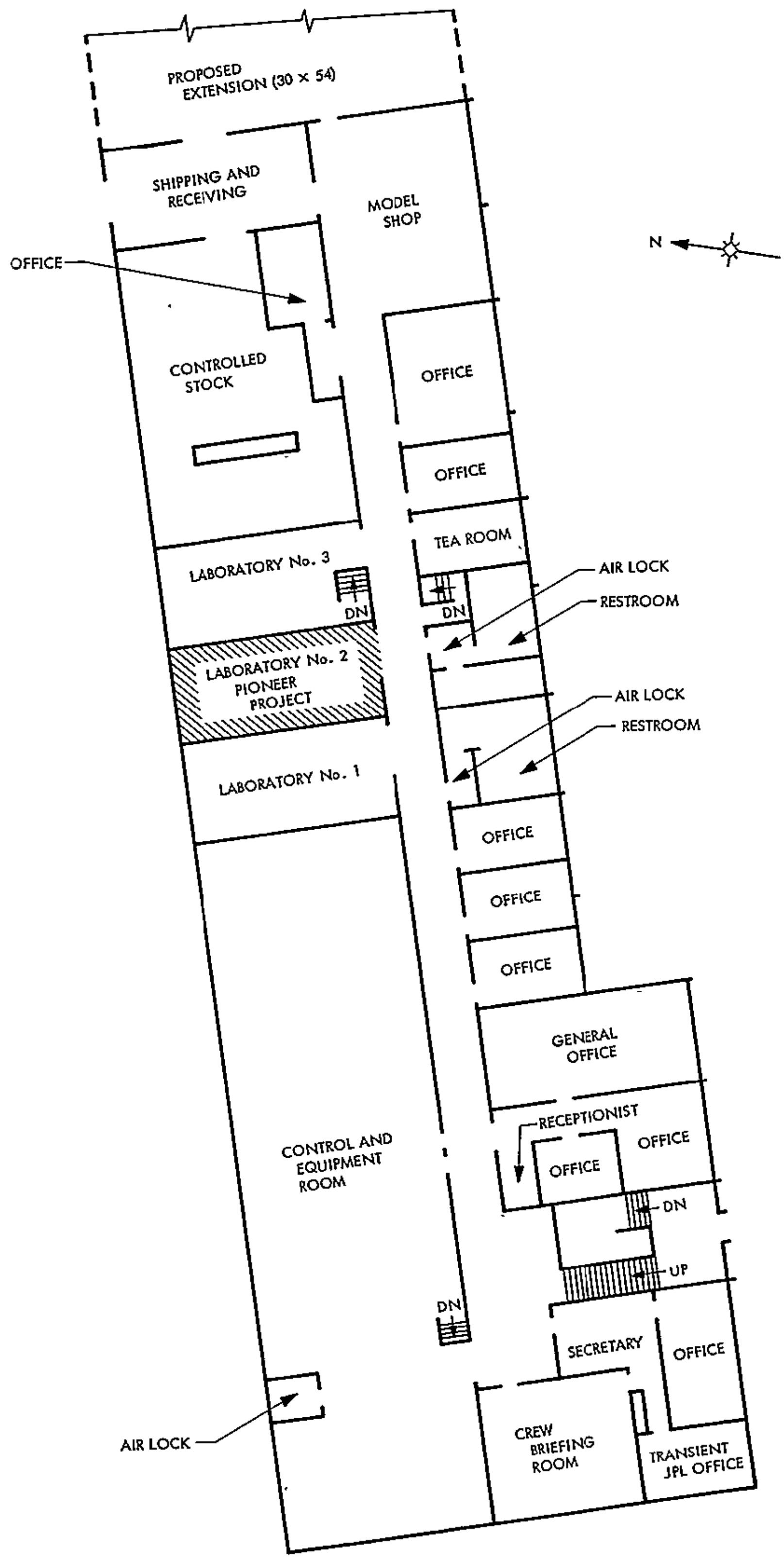



Fig. 26. DSS 42 operations and engineering building, Tidbinbilla, Australia

basis at other times. The maximum usable bit rate[2] on these circuits is 23 bits/s.

A full-time duplex teletype circuit and a voice circuit between the SFOF and the Tidbinbilla station are assigned for net control use by the DSIF. Subject to the approval of the station manager and the DSIF operations manager, or their delegates, these circuits may be used by *Pioneer* when they are not busy or during emergencies.

The Tidbinbilla station was to provide a voice communications circuit to interconnect the project-dependent equipment command operator with the station receiver, data handling, computer, transmitter, and antenna operators.

*DSS 12, Goldstone Echo.* The DSN was to provide an area of approximately 400 ft$^2$ in the control building for the exclusive use of the *Pioneer* for the installation of project-peculiar equipment (Fig. 27). Occupancy date

[2]This rate is derived as follows: Maximum teletype transmission rate is 60 words/min or 1 word/s. Each word contains 6 characters (5 letters plus one space), and each character contains 7 bits (1 start, 1 stop, 1 parity, 4 data). If line feed and carriage return characters are assumed to require an average of 1 bit/s, the usable bit rate (not counting the requirements for message preamble, identification, data/time groups, etc.) is $4 \times 6 - 1 = 23$ bits/s.

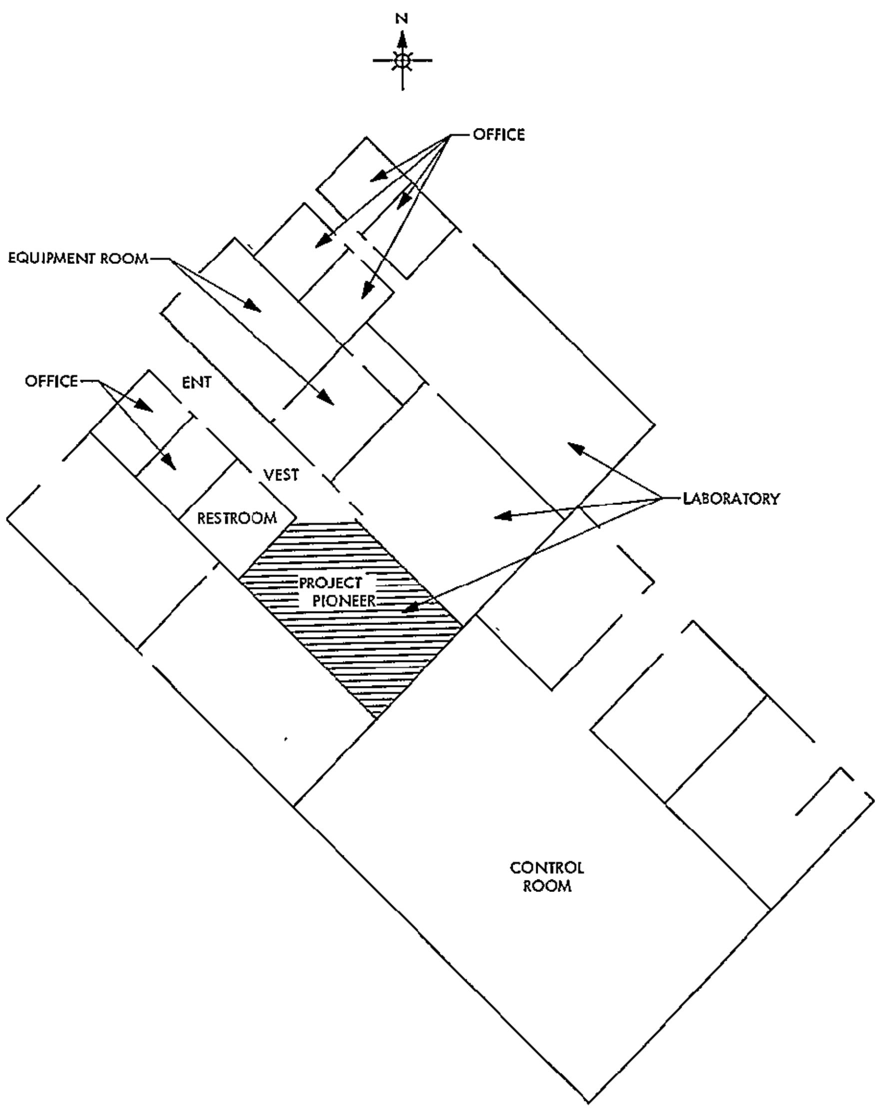



Fig. 27. DSS 12 control building, Goldstone, California

was April 1, 1965. The following facility support for this space was provided:

Power: 120 Vac ±10%, 60 ±1 Hz, with capacity sufficient for the project-peculiar equipment; 120 Vac, 60-Hz power outlets for auxiliary equipment.

Room temperature: 70 ±5°F.

Plenum air temperature: 55 ±5°F.

Humidity: 50 ±10% relative.

Lighting: 100 ft-cd.

Acoustic level: 75 dB above $10^{-16}$ W/cm$^2$ max.

The data system hardware commitment made to DSS 42 is applicable at this site.

It was agreed that the DSN will normally operate and maintain the project-dependent equipment supplied by *Pioneer* except during special events, such as an orientation maneuver, when the project manager at his option may furnish personnel to operate and maintain this equipment.

The DSN was to provide, subject to circuit priorities, two full-duplex teletype circuits between the SFOF and DSS 12 for full-time use by the *Pioneer* Project during a pass to which the station is assigned and on a shared basis at other times. The maximum usable bit rate on these circuits is 23 bits/s. During orientation maneuvers a third full duplex teletype circuit and a voice circuit will be made available for use by the project. A full-time duplex teletype circuit and a voice circuit between the SFOF and DSS 12 are assigned for net control by the DSIF. Subject to the approval of the station manager and the DSIF operations manager, or their delegates, these circuits may be used by the *Pioneer* Project when they are not busy or during emergencies.

The station was to provide a voice communications circuit to interconnect the project-dependent equipment orientation director and the spacecraft status advisor with the station manager and with the receiver, transmitter, antenna, computer, and data handling operators.

*DSS 51, Johannesburg, South Africa.* The DSN was to provide an area of approximately 300 ft$^2$ in the control building for the exclusive use of *Pioneer* for the installation of project-peculiar equipment (Fig. 28). Occupancy date was April 1, 1965. The following facility support for this area was provided:

Power: 120 Vac ±10%, 60 ±1 Hz, with sufficient capacity for the project-peculiar equipment; 120 Vac, 60-Hz power outlets for auxiliary equipment.

Room temperature: 70 ±5°F.

Plenum air temperature: 55 ±5°F.

Humidity: 50 ±10% relative.

Lighting: 100 ft-cd.

Acoustic level: 75 dB above $10^{-16}$ W/cm$^2$ max.

Similar commitments made to DSS 42 relative to data system hardware, project-dependent equipment, and communications equipment are applicable at this station.

*DSS 71, Spacecraft Monitoring Station, Cape Kennedy.* The DSN was to provide an area of approximately 300 ft$^2$ in the control building for the exclusive use of *Pioneer* Project for the installation of project-peculiar equipment (Fig. 29). Occupancy date was May 1, 1965. The following facility support for this area was provided:

Power: 120 Vac ±10%, 60 ±1 Hz with sufficient capacity for the project-peculiar equipment; 120 Vac, 60-Hz power outlets for auxiliary equipment.

Room temperature: 70 ±5°F.

Plenum air temperature: 55 ±5°F.

Humidity: 50 ±10% relative.

Lighting: 100 ft-cd.

Acoustic level: 75 dB above $10^{-16}$ W/cm$^2$ max.

DSS 71 was to be used to verify prelaunch compatibility of the spacecraft with the DSN during the prelaunch countdown.

The commitment made to DSS 42 relative to data system hardware and project-peculiar equipment is applicable at this station.

The DSN was to provide three half-duplex teletype and one voice circuit between the SFOF and the JPL communications center at Cape Kennedy for full-time use by *Pioneer* during launch operations. The maximum usable bit rate on the teletype circuits is 23 bits/s. During nonlaunch operation periods, the normal communications facilities maintained between JPL and Cape Kennedy will be available to *Pioneer* on a shared basis.

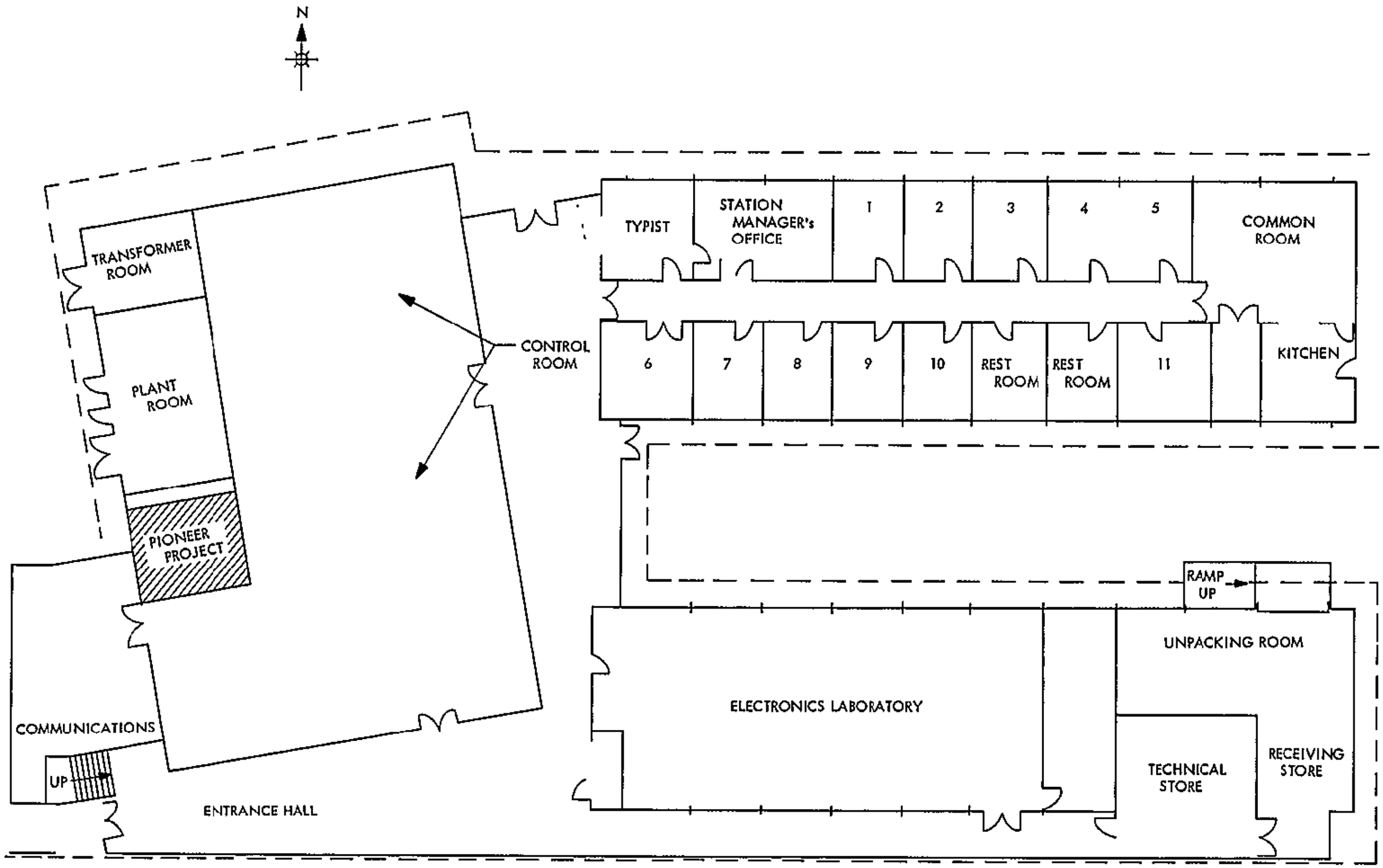



Fig. 28. DSS 51 control building, Johannesburg, South Africa

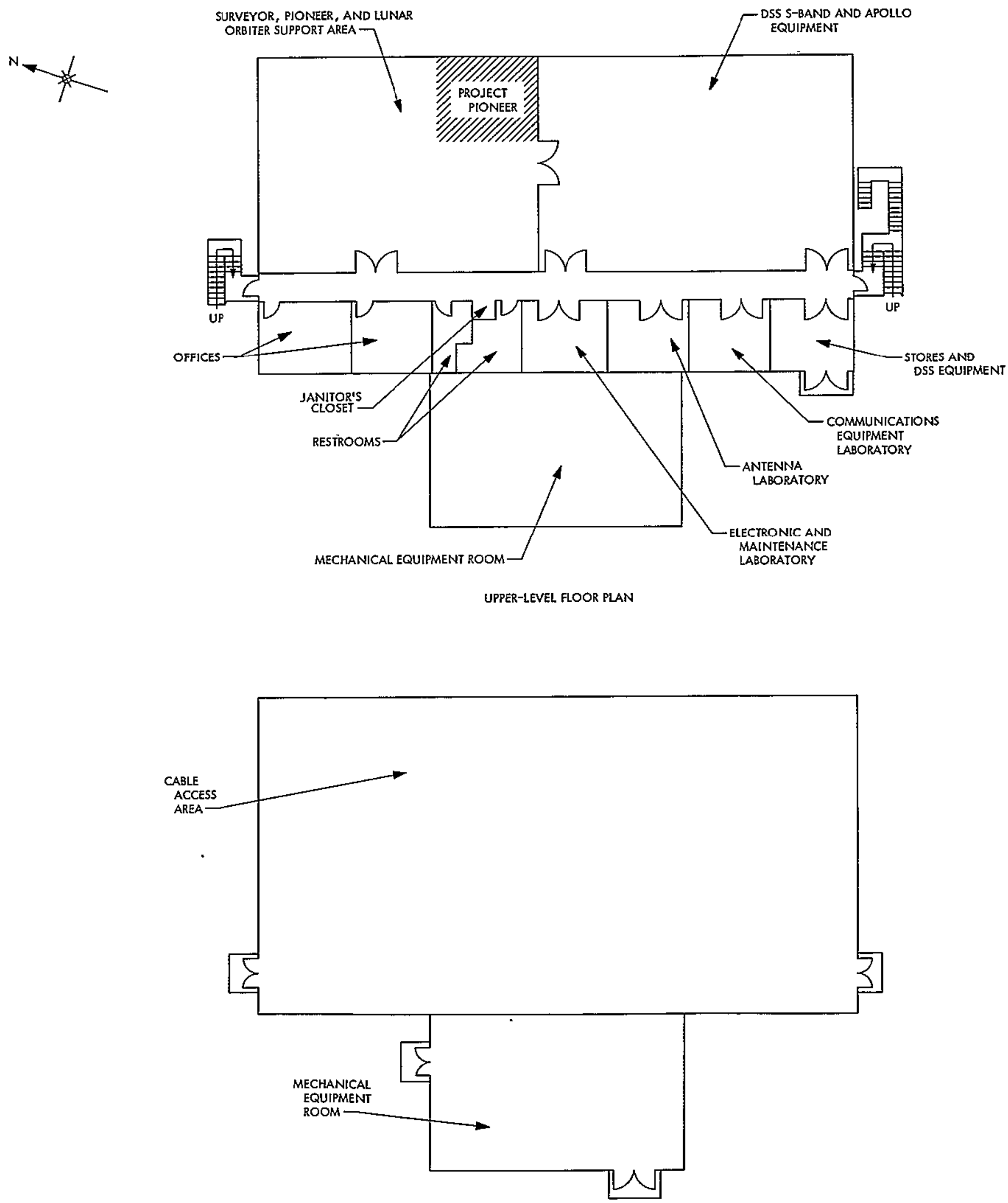
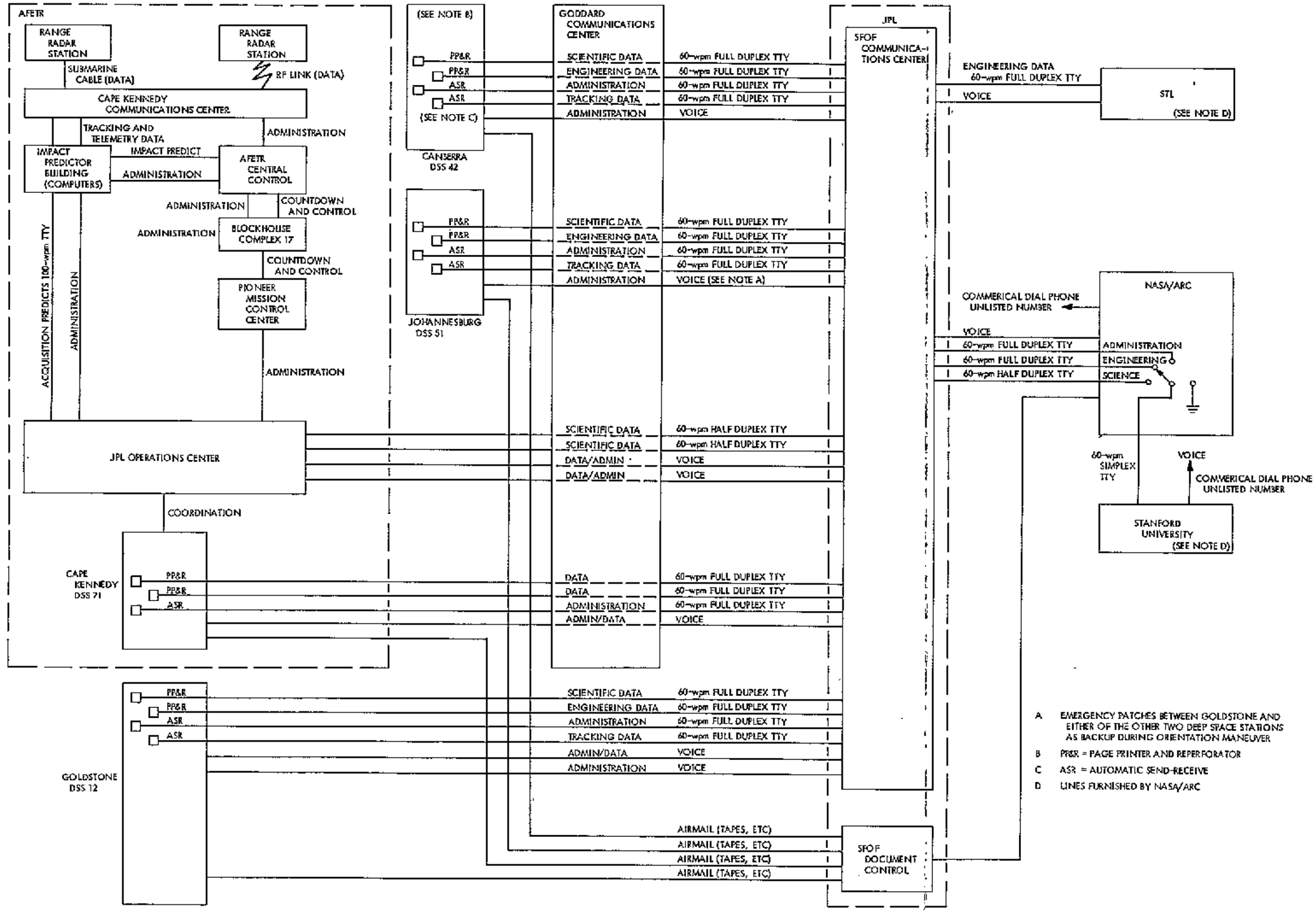



**Fig. 29. DSS 71 operations building, Cape Kennedy, Florida**




A EMERGENCY PATCHES BETWEEN GOLDSTONE AND EITHER OF THE OTHER TWO DEEP SPACE STATIONS AS BACKUP DURING ORIENTATION MANEUVER
B PP&R = PAGE PRINTER AND REPERFORATOR
C ASR = AUTOMATIC SEND-RECEIVE
D LINES FURNISHED BY NASA/ARC

**Fig. 30. *Pioneer VII* communications lines**



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The station was to provide a voice communications circuit to interconnect the project-dependent equipment operator with the station receiver, transmitter, data handling, computer, and antenna operators.

*2. Ground Communications Facility.* The DSN Ground Communications Facility (GCF) is the means by which the Deep Space Stations transmit data to and receive information from the SFOF. The GCF provides intra- and interfacilities communications and an overall operational communications complex for flight project support. GCF responsibilities for *Pioneer* include controlling, operating, and maintaining all circuits and switching and terminal equipment committed to *Pioneer.* GSFC has responsibility for technical control of all the NASCOM circuits used by the DSN. Technical control means maintenance of the communication network, including restoration of service and selection of alternate routes when available. In fulfillment of the responsibility for technical control, GSFC informs JPL of the availability and condition of alternate circuits during periods of use, but does not perform the actual switching without prior approval of JPL. JPL has responsibility for mission control of the NASCOM circuits used by the DSN. "Mission control" implies the determination of (1) what traffic will flow, (2) when and to what points this traffic will flow, and (3) on what circuits the flow will occur. Communication lines between the various DSIF stations and the SFOF are shown in Fig. 30. The AFETR communications and circuits to ARC, Stanford University, and STL are also shown.

*a. Circuits.* At the time of launch, all allocated circuits were ready to support the mission. Figure 30 shows the communications lines between the various agencies supporting *Pioneer VII.*

*b. Personnel.* Through the media of simulation testing, local communications personnel have become familiar with project-peculiar requirements. These personnel, therefore, were qualified to support the project in the desired manner by launch date.

*c. Procedures.* Normal communications procedures involving facility configuration freeze and NASCOM special coverage were provided for the launch period.

*3. Space Flight Operations Facility.* The SFOF is a flexible facility in which areas and hardware can be configured and reconfigured to meet the needs of various projects.

*a. Areas.* The DSN, in meeting the requirements of the *Pioneer VII* mission, will utilize the following areas indicated in Fig. 31:

(1) *Pioneer* mission support area (mission-dependent) rooms 132, 132A.

(2) Operations area, room 113.

(3) Mission control, room 2.

(4) Flight path analysis area (FPAA), room 117.

(5) Project manager, room 115A.

(6) Gallery.

(7) DSIF control, rooms 101, 101A.

(8) DSN control, room 118.

*Pioneer mission support area.* This area is to be used as the operational control center during the low-activity (cruise) phase. Spacecraft performance analysis and space science analysis will be accomplished in this area (Figs. 32 and 33).

The DSN was to provide an area approximately 40 ft by 35 ft, called mission support area 4, on the first floor of the SFOF, to the *Pioneer* Project for its exclusive use. Occupancy was June 1, 1965. Included in this area is a 10- by 12-ft walled conference room. Location and configuration of this area are shown in Fig. 31. The DSN was to install the following equipment in *Pioneer* mission support area:

1 console, operations with operational voice communications subsystem (OVCS).

3 consolettes (TV monitor, channel selector, and OVCS).

6 monitors, TV for general display.

2 monitors, TV for time display.

1 camera, TV, hard copy.

5 intercom and telephone sets, OVCS.

4 printers, teletype page with selector box.

1 printer/sender, teletype keyboard send–receive unit with selector box.

1 reader, teletype transmitter–distributor (tape reader).

2 reperforators, teletype (tape punches).

In addition, the DSN was to furnish a TV time display camera.

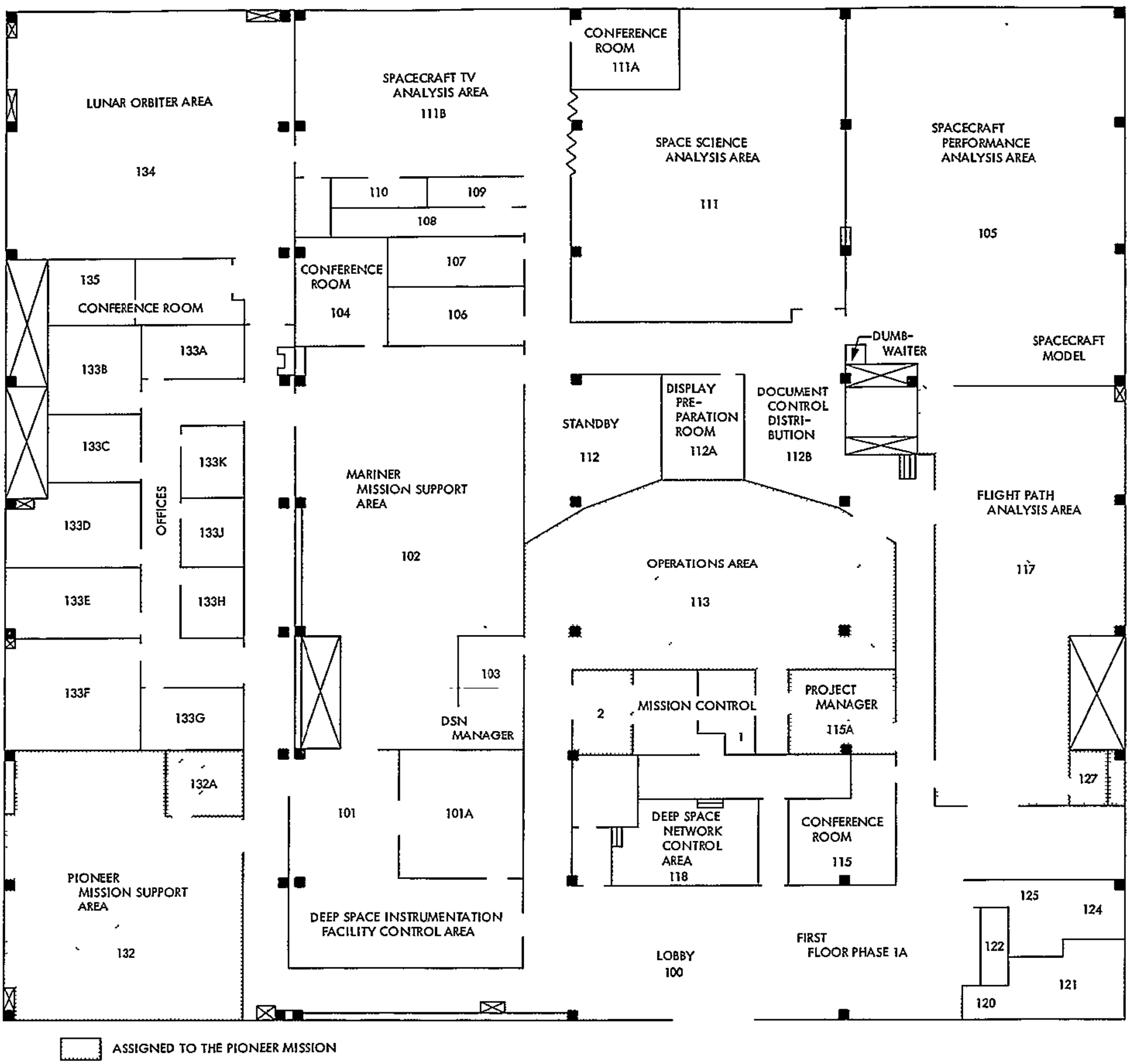



Fig. 31. First floor, SFOF

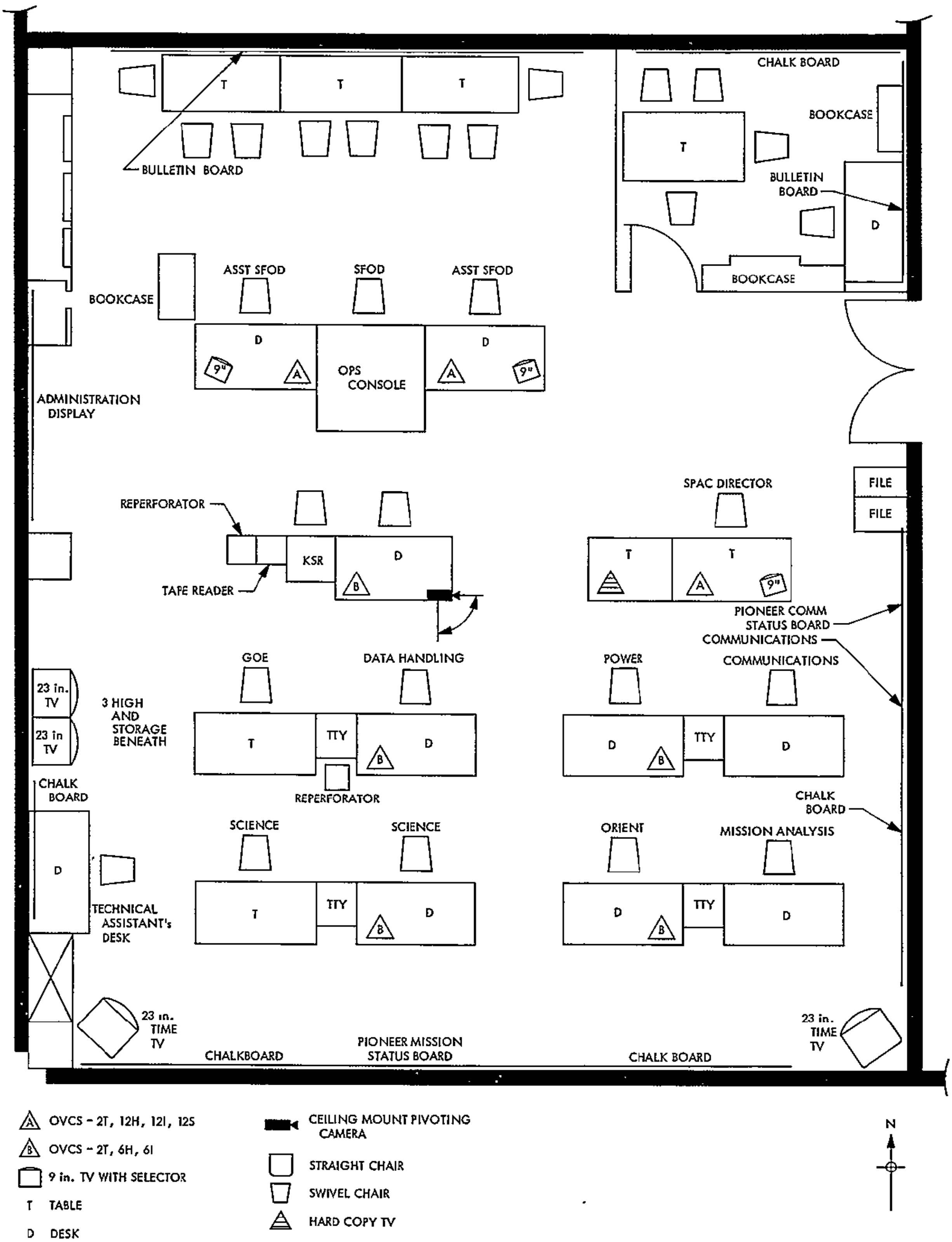



Fig. 32. *Pioneer* mission support area

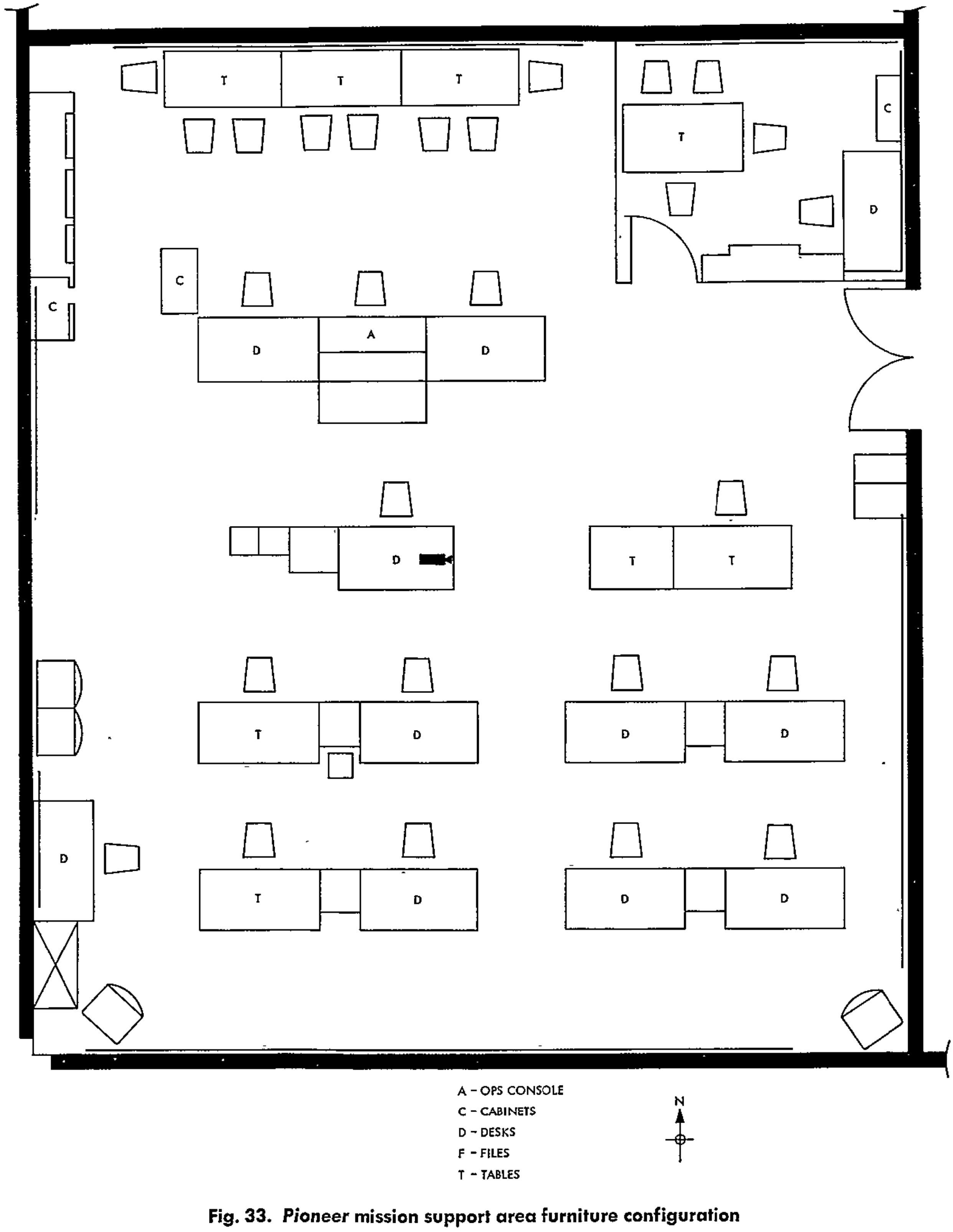



Fig. 33. *Pioneer* mission support area furniture configuration

One of the mission control rooms with all of its support facilities and a flight path analysis area (see Fig. 31) was to be available for support of *Pioneer* during critical phases of each mission. These phases include launch, orientation maneuvers, and system tests. Availability of these facilities is subject to priority arrangements with other flight projects.

Standard DSN operational voice communications were to be provided to the project in all areas assigned to the project. Terminations at the SFOF for teletype and voice circuits between ARC, Stanford, and/or STL and the SFOF were to be provided by the DSN.

The DSN was to make dubbed recordings of the original magnetic tape recordings made at the DSIF stations. These recordings are shipped to the *Pioneer* Project at ARC.

*Operations area and mission control room 2.* These areas will be used only in high-activity phases (launch and orientation).

*Flight path analysis area (FPAA).* The configuration of the FPAA (Fig. 34) is in accordance with the requirements of the *Pioneer* Project. Numerous flight path tests have demonstrated the adequacy of this configuration.

*b. Systems.* The following systems will support the *Pioneer* mission, as required: (1) data processing, (2) communications, (3) support.

*Data processing system (DPS).* The only tasks for the general DPS to perform for support will be the processing of tracking data for the establishment of a maximum-accuracy orbit and for DSIF predicts. The DPS is prepared to assume these tasks.

*Telemetry processing station (TPS).* The TPS is preparing to process data for validation purposes. The TPS will receive telemetry magnetic tapes for reproduction. During the reproduction (duplicating) process, the TPS will provide data validation to monitor and verify recording levels and to inspect recorded data as to its continuity.

A data log on each tape will be generated containing the following indications:

(1) Receiver flag (a time printout occurring each time there is a receiver out-of-lock state).

(2) Demodulator flag (a time printout occurring each time there is a demodulator out-of-lock state).

(3) Time flag (an error printout occurring when the delta time disagrees with the data rate).

All validation will be done on the duplicated tape. After processing, the TPS will return the original tapes along with the duplicate and one copy of the data log to the SFOF operational document control (ODC) office for shipment to the *Pioneer* Project Office.

*c. Intracommunications.* All areas within the SFOF assigned to *Pioneer* have a complete complement of communications devices. Figures 35, 36, and 37 show teletype, closed-circuit TV, and operational voice communications subsystems locations within the *Pioneer* mission support area.

*d. Support systems.* The DSN/SFO support system includes:

(1) Electrical and air-conditioning system. These systems, including the backup power system, have been maintained in the normal manner and are ready to support *Pioneer* requirements in the SFOF.

(2) Displays. The SFOF operations group prepares all displays that are not the responsibilities of the DPS and communications personnel. All displays are operational. These displays include those in the FPAA.

(3) Operational document control (ODC). In its non-real-time, mission-independent function, ODC will receive, log, and distribute data from the deep space stations. Data will be forwarded to the TPS for processing. After processing, ODC will prepare the data packages for shipment to ARC.

(4) Technical assistance. At least one technical area assistant is provided, as requested, in the *Pioneer* mission support area. The functions of the assistant include the distribution of data printouts throughout the area, the maintenance of teletype machines in the area, and the performance of other miscellaneous duties pertinent to *Pioneer*.

(5) Scheduling. Areas and equipment are ready for operations according to the DSN utilization schedule and the DSN 10-day schedule.

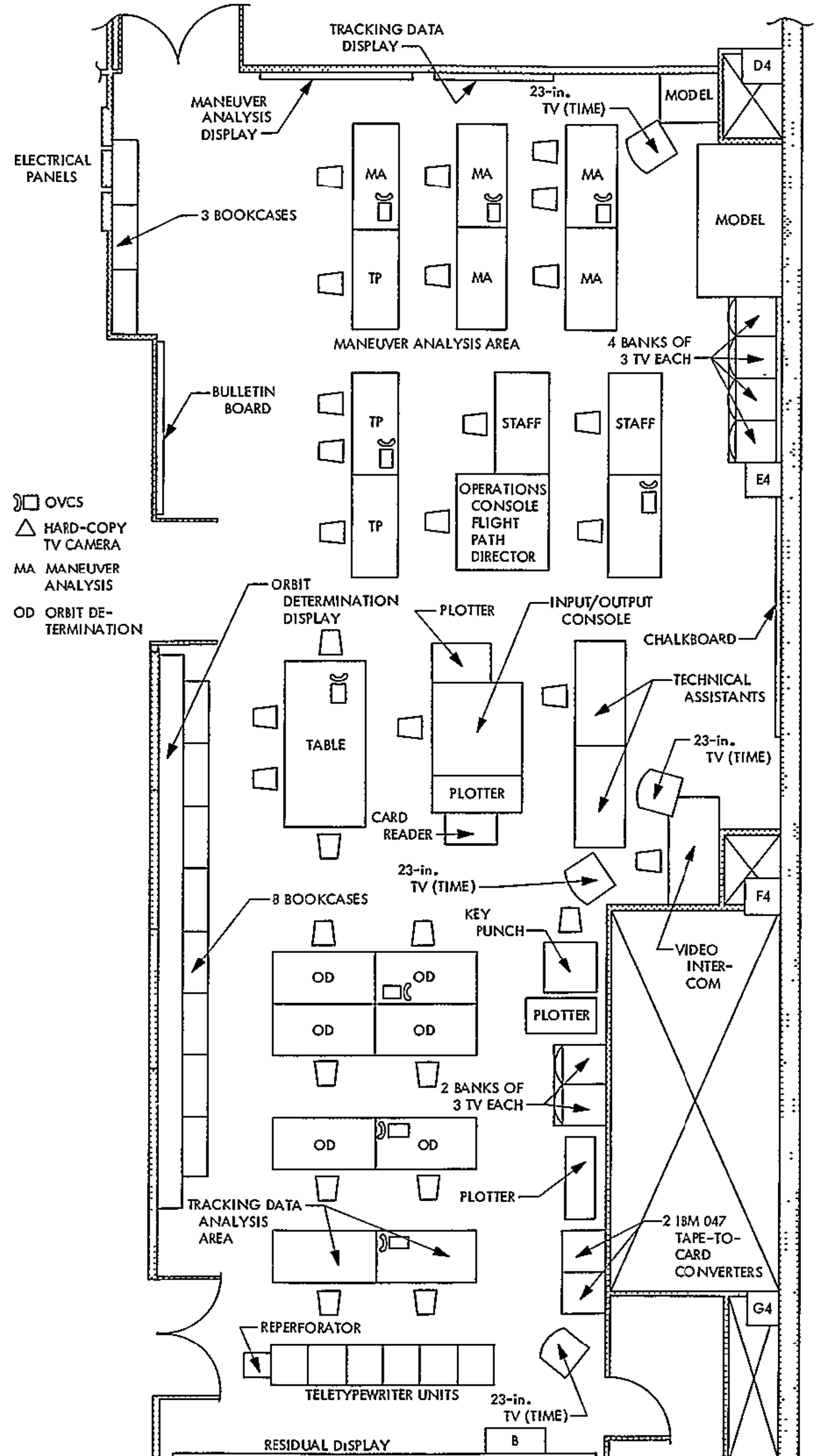
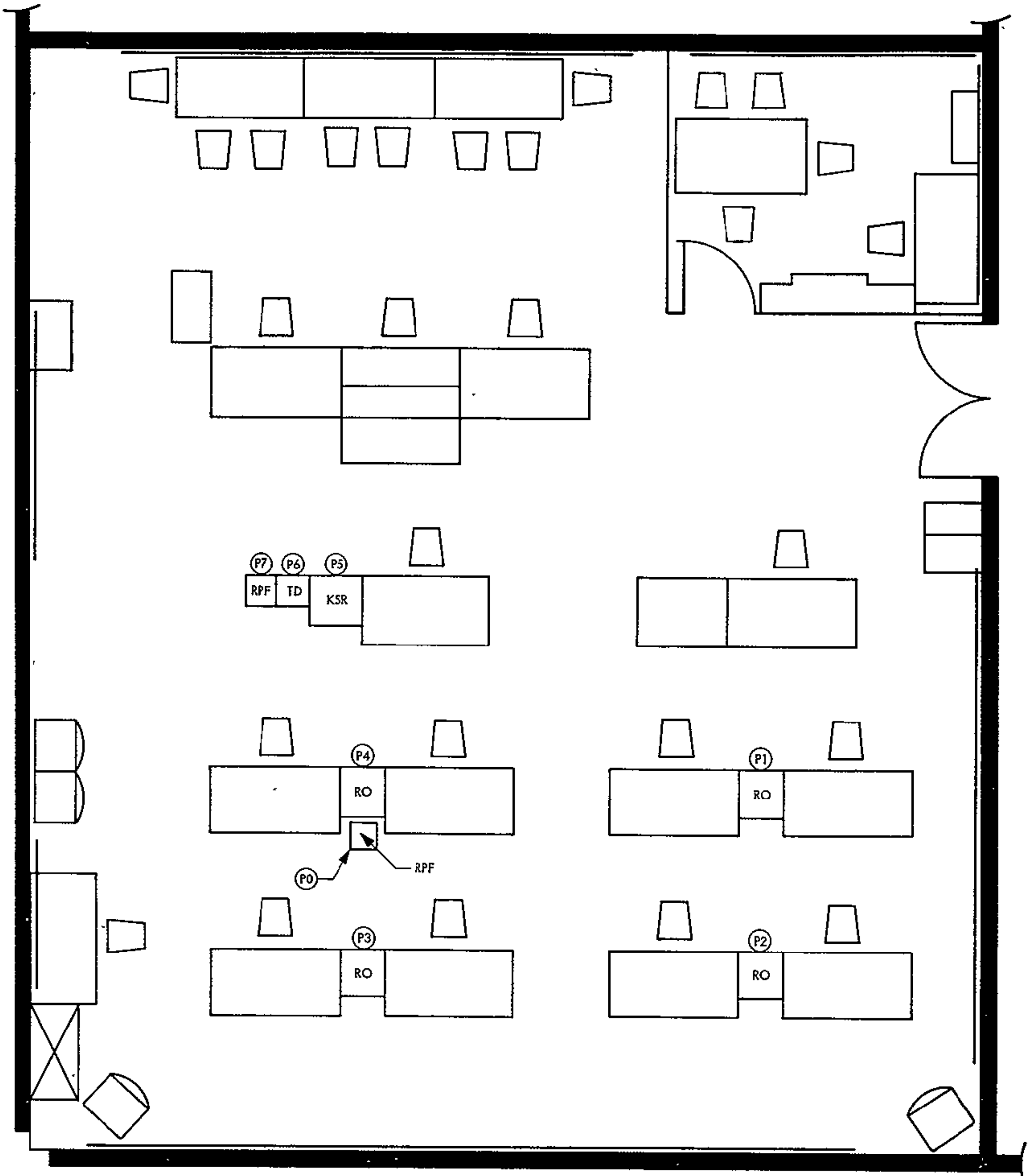



Fig. 34. Flight path analysis area




RO - RECEIVE ONLY SET
TD - TRANSMITTER DISTRIBUTOR SET
RPF - REPERFORATOR SET
KSR - KEYBOARD SEND/RECEIVE SET
(XX) - SET DESIGNATION

**Fig. 35. *Pioneer mission support area, teletype locations***

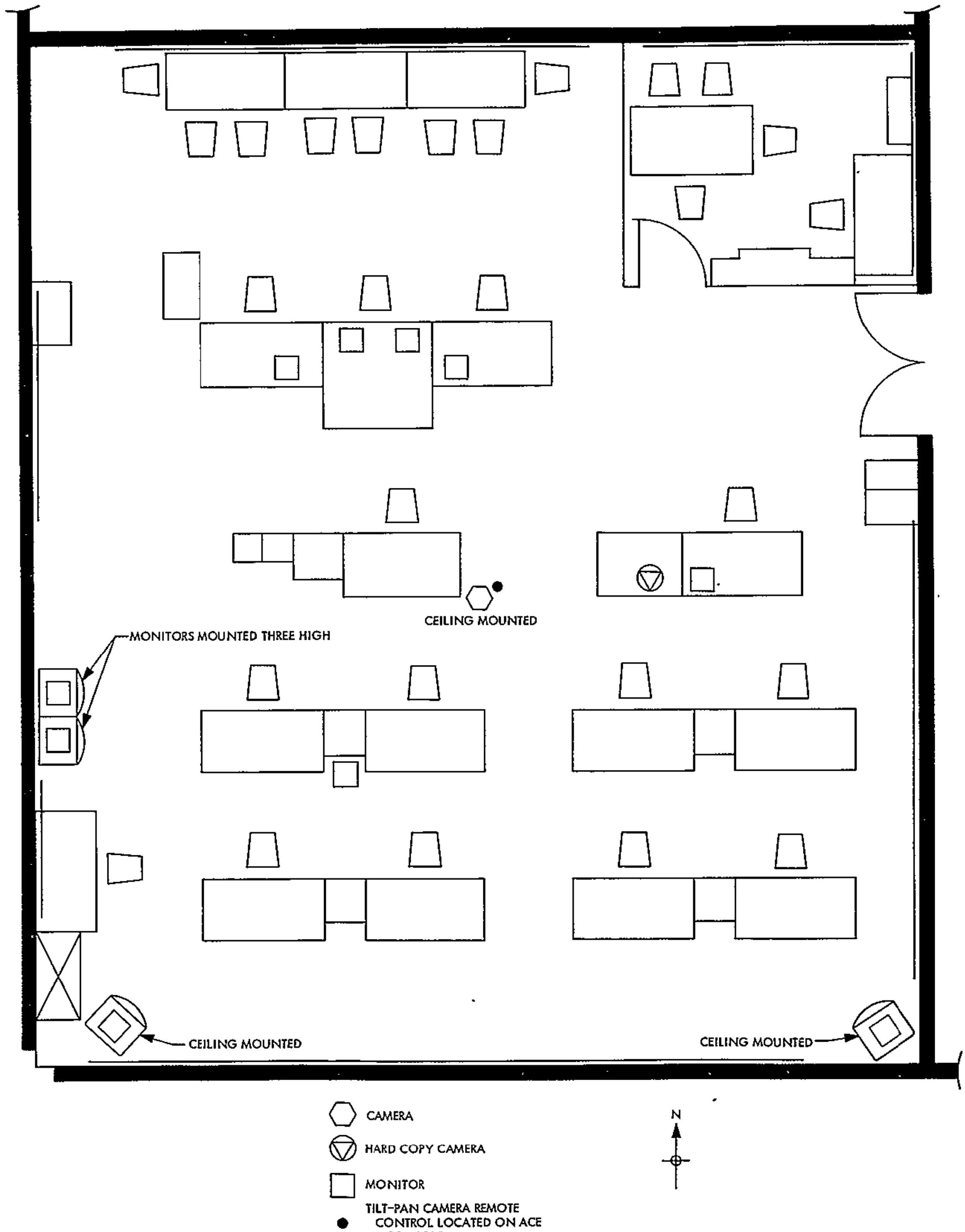



**Fig. 36.** ***Pioneer*** **mission support area, closed-circuit TV locations**

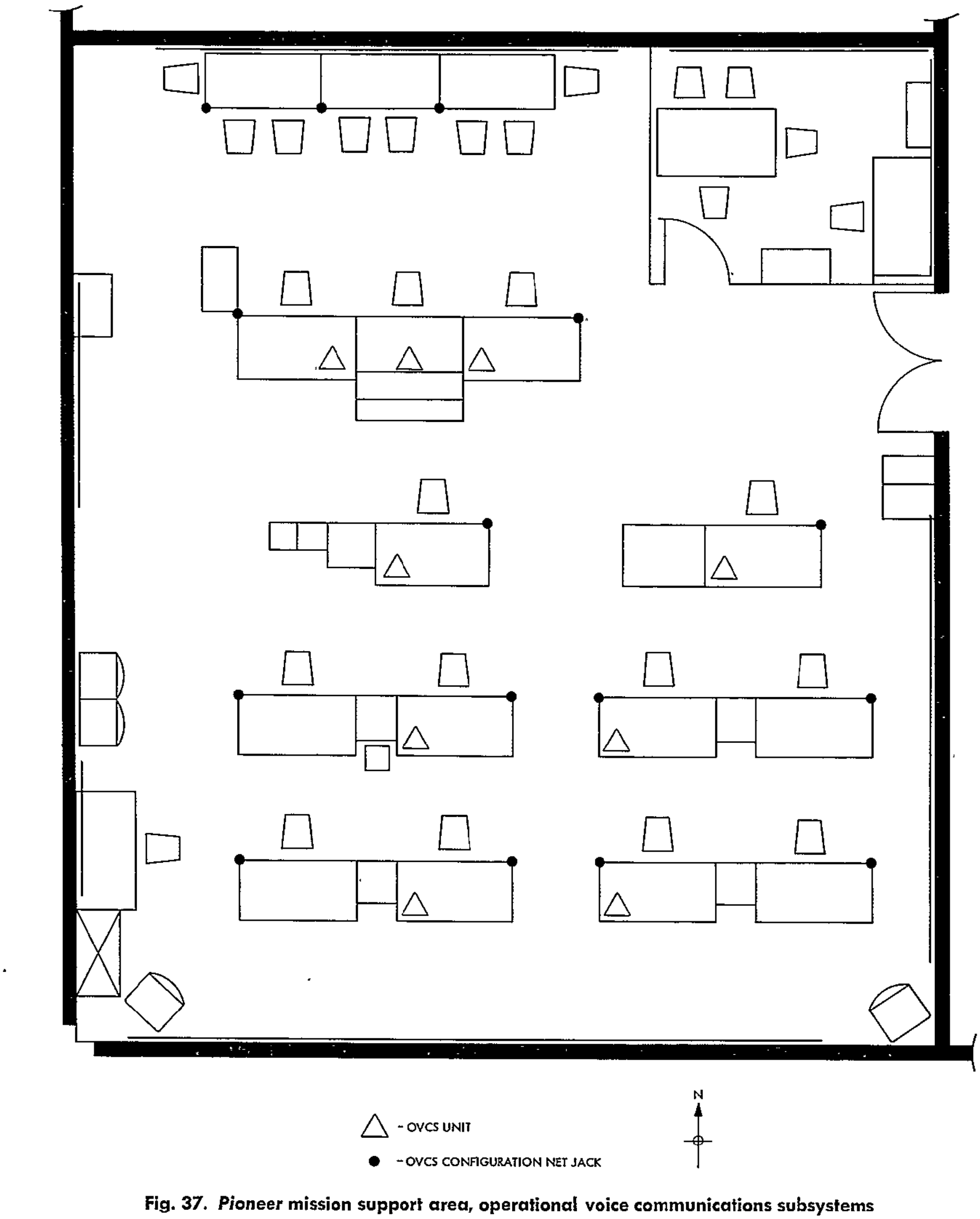



Fig. 37. *Pioneer mission support area, operational voice communications subsystems*

*e. Data processing system.* The SFOF DPS is organized into four subsystems: the computer subsystem (Fig. 38), the telemetry processing station subsystem, the data processing control and display subsystem, and the programming subsystem. The only tasks performed in support of *Pioneer* by the SFOF DPS are the processing of tracking data for the establishment of a medium accuracy orbit and Deep Space Station predicts. All other processing of data, except for the science data is done at the Deep Space Stations with the SDS-910 computers.

*Data flow.* Figure 14 shows the typical routing and flow of the telemetry and tracking data acquired by the AFETR and DSIF. This data is then routed through the SFOF to its final destination.

*Engineering data.* This data is processed at the deep space stations by the SDS-910 computers. The data is encoded in English, the language format, and selected portions are transmitted to the SFOF by teletype (Fig. 39). At the SFOF it is relayed in real-time directly to the *Pioneer* mission support area, to ARC, and to STL. The computer-selected class I engineering measurements printed out in the mission support area and other selected data are then routed to the various agencies. Figure 40 shows the complete data flow from the SFOF. The engineering data received in the SFOF *Pioneer* mission support area is analyzed by ARC and STL personnel.

*Scientific data.* This data is separated from the engineering data subcommutator at the DSIF sites by the 910 computers. It is recorded on magnetic tapes. A duplicate of this tape is mailed to the SFOF, and from there it is forwarded to ARC for computer processing. Scientific data analysis is performed at NASA/ARC by NASA representatives and the experimenters.

*Flight path data.* During the launch phase (less than 24 h) the following activities are carried out:

(1) Continuous transmission of tracking data from each Deep Space Station committed to track the *Pioneer* spacecraft.

(2) Mode I operation of the SFOF DPS until predicts for one day have been prepared, shifting to mode IIA for the remainder of the launch phase.

(3) A fully manned FPAC team in real-time operation until predicts for three days have been prepared. (Tracking data from about half of the first Goldstone pass is required before the launch phase is considered completed.)

From completion of launch phase through step II reorientation plus 1 day (about 10 days after launch), the following activities are carried out:

(1) Batch transmission of tracking data from each DSIF station committed to track the *Pioneer* spacecraft, with "on call" continuous transmission of tracking data, if required by the FPAC team.

(2) Mode IIIA operation of the SFOF DPS when tracking data is being transmitted.

(3) Determination of an orbit each day by FPAC and preparation of predicts for 10 days, if necessary, using a mode IV configuration of the SFOF DPS.

After completion of type II orientation, the following activities are carried out:

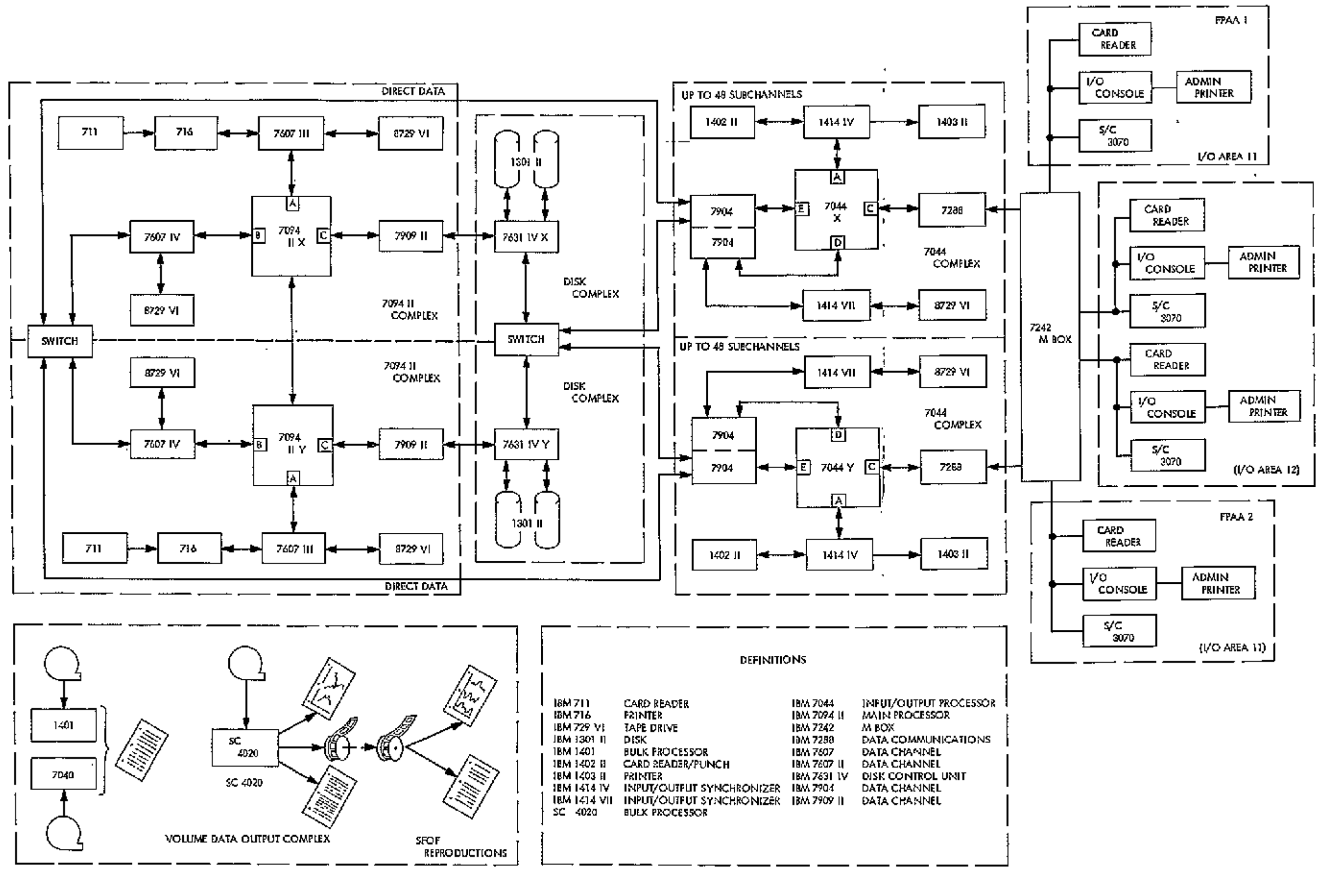
(1) Batch transmission to track the *Pioneer* spacecraft.

(2) Mode IIIB operation of the SFOF DPS when tracking data is being transmitted.

(3) Determination of an orbit once a week by FPAC and preparation of predicts for 10 days, using mode IV operation of the SFOF DPS.

*f. ARC/data processing.* As previously stated, the volume of telemetry data from the spacecraft together with other information and measurements made at the Deep Space Station and required by the data user is too large for teletype transmission to the central processing station and subsequent dissemination to the user. The data is transmitted primarily by shipment of magnetic tapes. This data flow, indicated functionally in Fig. 41, begins when the spacecraft telemetry and other necessary information is recorded on two FR-1400 tape recorders operating in parallel at the Deep Space Station. The time for tape loading on each machine is staggered to avoid loss of data during such periods. One set of tapes, selected to contain all data received, is then shipped to JPL, where it is examined to insure the quality of the reproduction. These tapes are then shipped to the *Pioneer* off-line data processing station at ARC for data processing and subsequent dissemination to the user.

The data is processed at ARC in a two-level system. The first level translates the seven channels of data on the FR-1400 tapes into a digital format. The equipment used includes a tape playback machine, a demodulator synchronizer, three racks containing digital logic, and an SDS-910 digital computer and associated peripheral equipment. This equipment, known collectively as the




DEFINITIONS

| | | | |
|---|---|---|---|
| IBM 711 | CARD READER | IBM 7044 | INPUT/OUTPUT PROCESSOR |
| IBM 716 | PRINTER | IBM 7094 II | MAIN PROCESSOR |
| IBM 729 VI | TAPE DRIVE | IBM 7242 | M BOX |
| IBM 1301 II | DISK | IBM 7288 | DATA COMMUNICATIONS |
| IBM 1401 | BULK PROCESSOR | IBM 7607 | DATA CHANNEL |
| IBM 1402 II | CARD READER/PUNCH | IBM 7607 II | DATA CHANNEL |
| IBM 1403 II | PRINTER | IBM 7631 IV | DISK CONTROL UNIT |
| IBM 1414 IV | INPUT/OUTPUT SYNCHRONIZER | IBM 7904 | DATA CHANNEL |
| IBM 1414 VII | INPUT/OUTPUT SYNCHRONIZER | IBM 7909 II | DATA CHANNEL |
| SC 4020 | BULK PROCESSOR | | |

**Fig. 38: Computer subsystem**



FOLDOUT FRAME 2



FOLDOUT FRAME 1

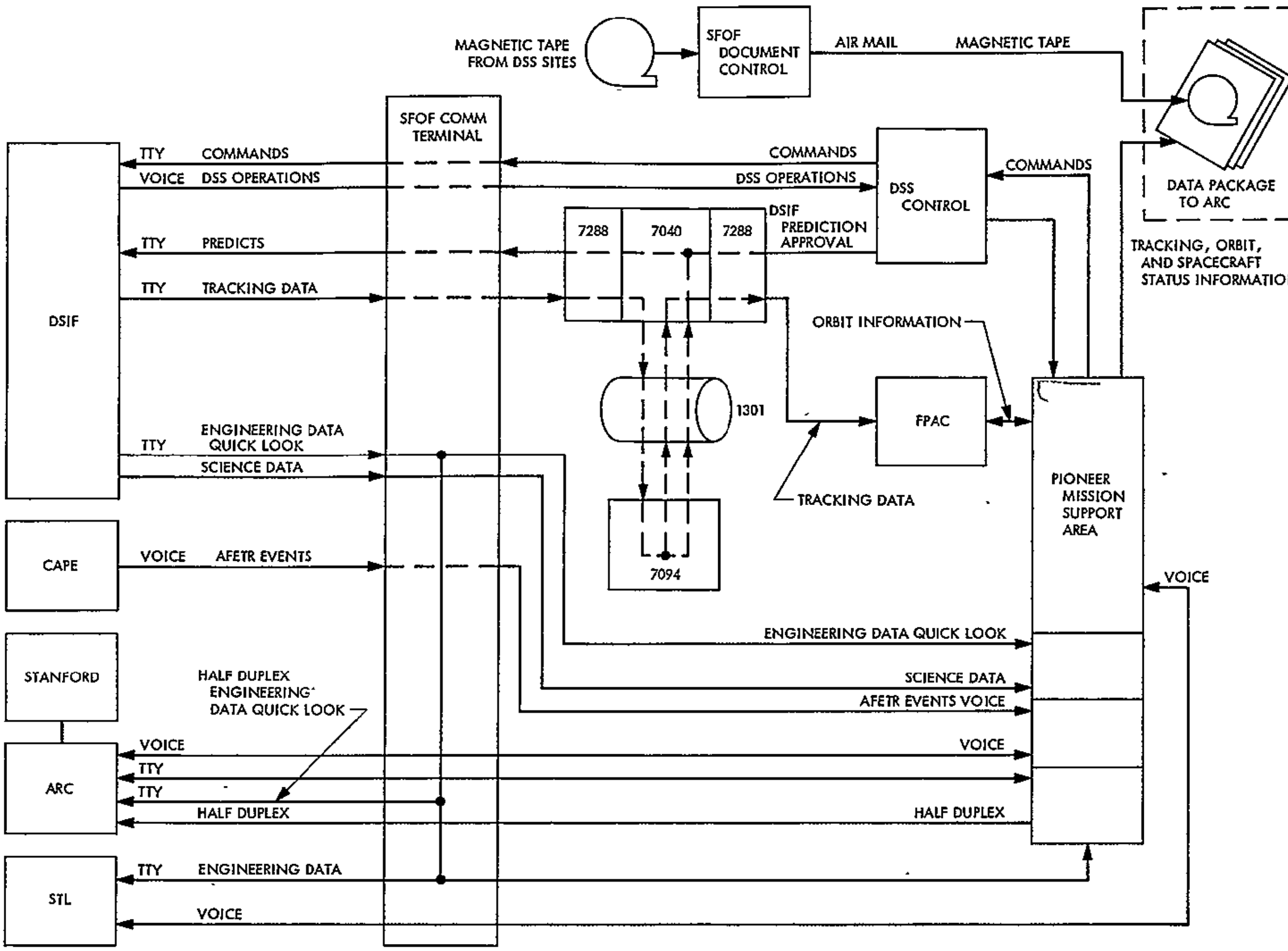



**Fig. 39. *Pioneer* SFOF data flow**

tape processing station, can process data from any Deep Space Station, whether or not it is equipped with GOE.

The output of the tape processing station, a multifile digital tape, is the input to the second level of processing. This level utilizes an IBM direct-coupled 7040/7094 and consists of timing the data, checking the spacecraft-word parity, validating the commands sent to the spacecraft, qualifying the data on the basis of the ground station parameters measured at the Deep Space Station, and decommutating the data stream so that each experimenter receives only data from his instrument and any of the telemetered engineering data required. This output data is recorded on a digital magnetic tape in a format and density compatible with the particular computer system each experimenter uses to analyze his data.

In addition to the spacecraft telemetry data, a trajectory tape is also sent to the experimenters several times during the mission. This periodically updated information, originating at JPL, contains spacecraft position in three coordinate systems as a function of time. The data on the tape is reprocessed at ARC and put into the format and density compatible with each experimenter's computer facility.



## IV. *Pioneer VII* Preflight Test Program

As with *Pioneer VI*, the *Pioneer VII* mission required a great deal of preflight testing support in an effort to insure a mission success. With the *Pioneer VII* launch, approximately 2 yr of intensified testing and effort was culminated.

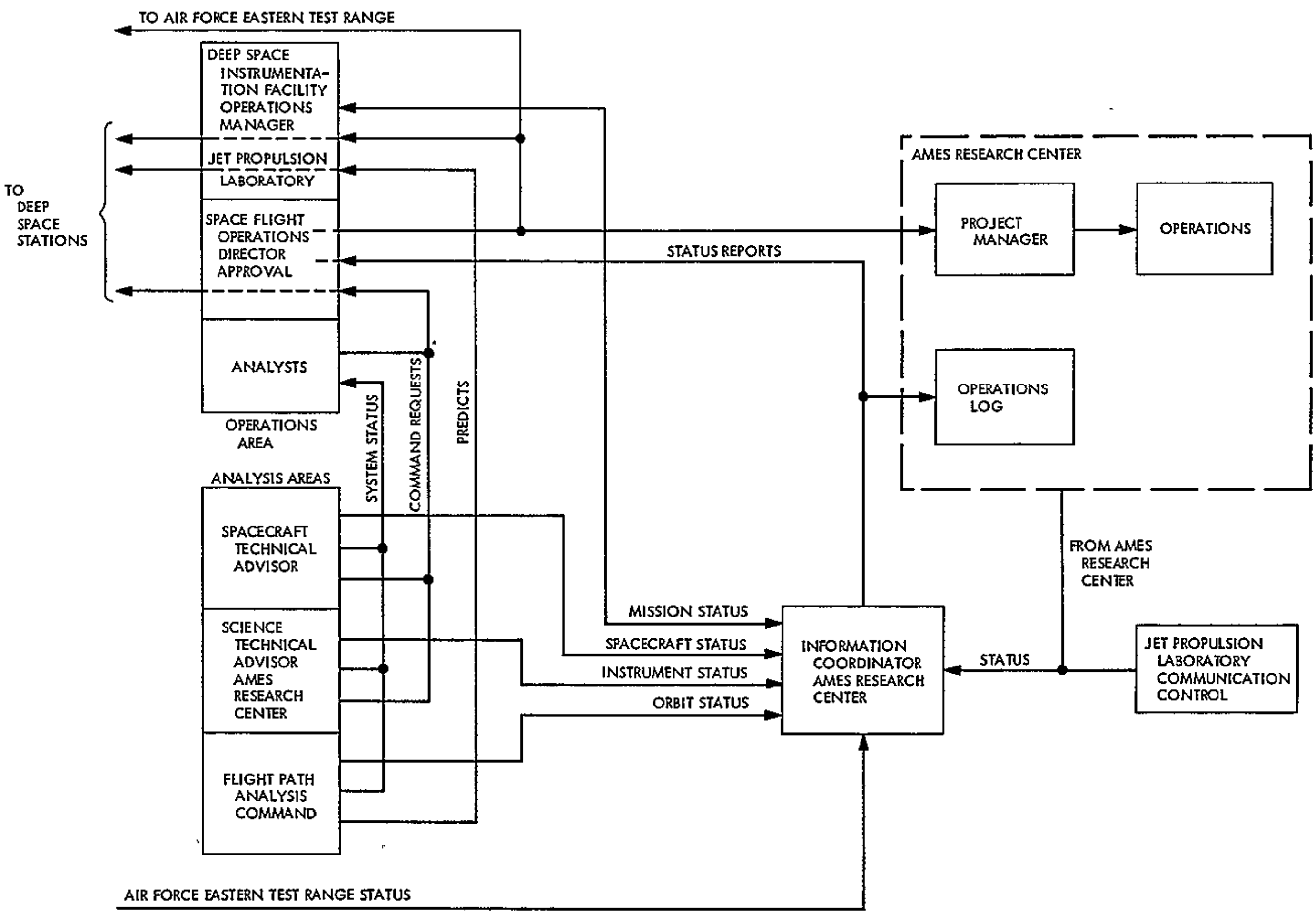



**Fig. 40. Complete data flow from the SFOF**

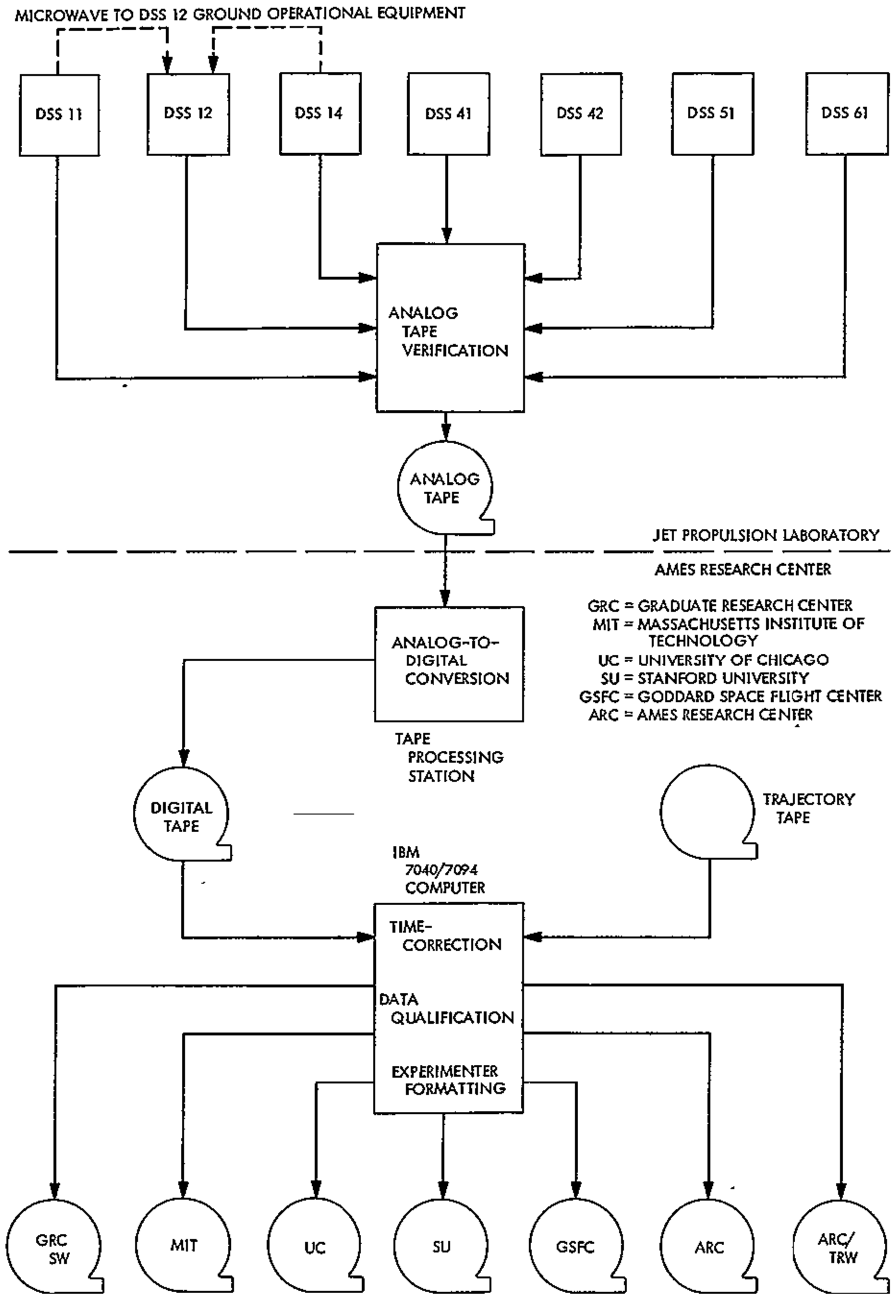



**Fig. 41.** ***Pioneer*** **off-line data processing system**

### A. Preflight Review

One of the major *Pioneer VII* program evaluation meetings, the preflight review, was held at TRW Systems, Redondo Beach, California. Participants included representatives of NASA Headquarters, GSFC, JPL, ARC, the experimenters, and TRW. The purpose of the meeting was: (1) to review the program, (2) to evaluate the preparedness of the spacecraft and instruments for commencement of launch activities at Cape Kennedy, and (3) to obtain approval from the participating agencies for shipping the spacecraft and instruments to Cape Kennedy.

During the preflight review, the spacecraft and instrument development programs were described in detail to provide assurance of the suitability of the design to accomplish the mission objectives and the reliability of the design to achieve long lifetime. Events occurring during the three design reviews and the use of breadboard and engineering models of the spacecraft and instruments during the development phase were discussed.

The test program was discussed in detail during the preflight review so that its adequacy in evaluating the reliability and quality of the equipment could be determined. The test program for both the spacecraft and scientific instruments was described with the aid of a test-flow diagram (Fig. 42). It was explained during the discussion that all equipment destined to be flight hardware had been acceptance-tested at the assembly level and then at the system level at expected flight environmental conditions, whereas the qualification assemblies and prototype spacecraft had been tested at environmental conditions more severe than those to be encountered in flight.

Prior to discussion of test results, the philosophy of the *Pioneer* program pertaining to "failures" was explained to the reviewers. Any nonconformance to specifications, malfunctions, defects, improper test setups, procedural errors, anomalous test data, etc., had been classified as "failures." All such failures had required a formal review and evaluation by a failure review board.

During the review meeting, all failures of the spacecraft and instrument assemblies since fabrication and the corrective actions and retest results were reviewed. The malfunctions which had occurred during the system testing of the spacecraft were summarily corrected. A study of these malfunctions showed that a large portion were minor electrical malfunctions and had been corrected as they occurred. It was concluded that the majority of problems would not have affected or degraded the objectives of this mission because of the presence of redundant equipment.

There were no open items from the failure review board on any of the scientific instruments at the time of the preflight review. However, there was some concern because it has been necessary on several occasions to transmit calibration commands to the GSFC magnetometer several times before the command was executed. (Subsequent to the review, it was learned that this characteristic was a peculiarity of instrument operation and not a malfunction.)

Based on the information presented, it was concluded by the participating agencies that although some problems remained to be resolved the spacecraft and instrumentation were flightworthy.

### B. Air Force Eastern Test Range

The AFETR prelaunch testing operations, the milestones, and the significant prelaunch events for *Pioneer VII* are presented in this section.

*1. Dual composite test.* No major anomalies occurred during the dual composite testing that was carried on for *Pioneer VII*. A normal start sequence was obtained, and the testing proceeded according to schedule.

*2. Acceptance and RFI test.* This portion of the test program was carried out with speed and proficiency. There were no serious problems encountered, and the testing was carried out to completion.

*3. All systems test.* The performance of this test was smoothly executed with no significant problems reported.

*4. Electrical systems test.* No problems were encountered during this test.

### C. Deep Space Network Testing

The tests that were conducted to insure the readiness of all elements of the DSN committed to support the *Pioneer VII* mission are classified as follows: (1) telemetry and command system acceptance tests, (2) subsystem acceptance tests, (3) integration tests, and (4) operational readiness tests. The breakdown of tests performed is presented in Table 16.

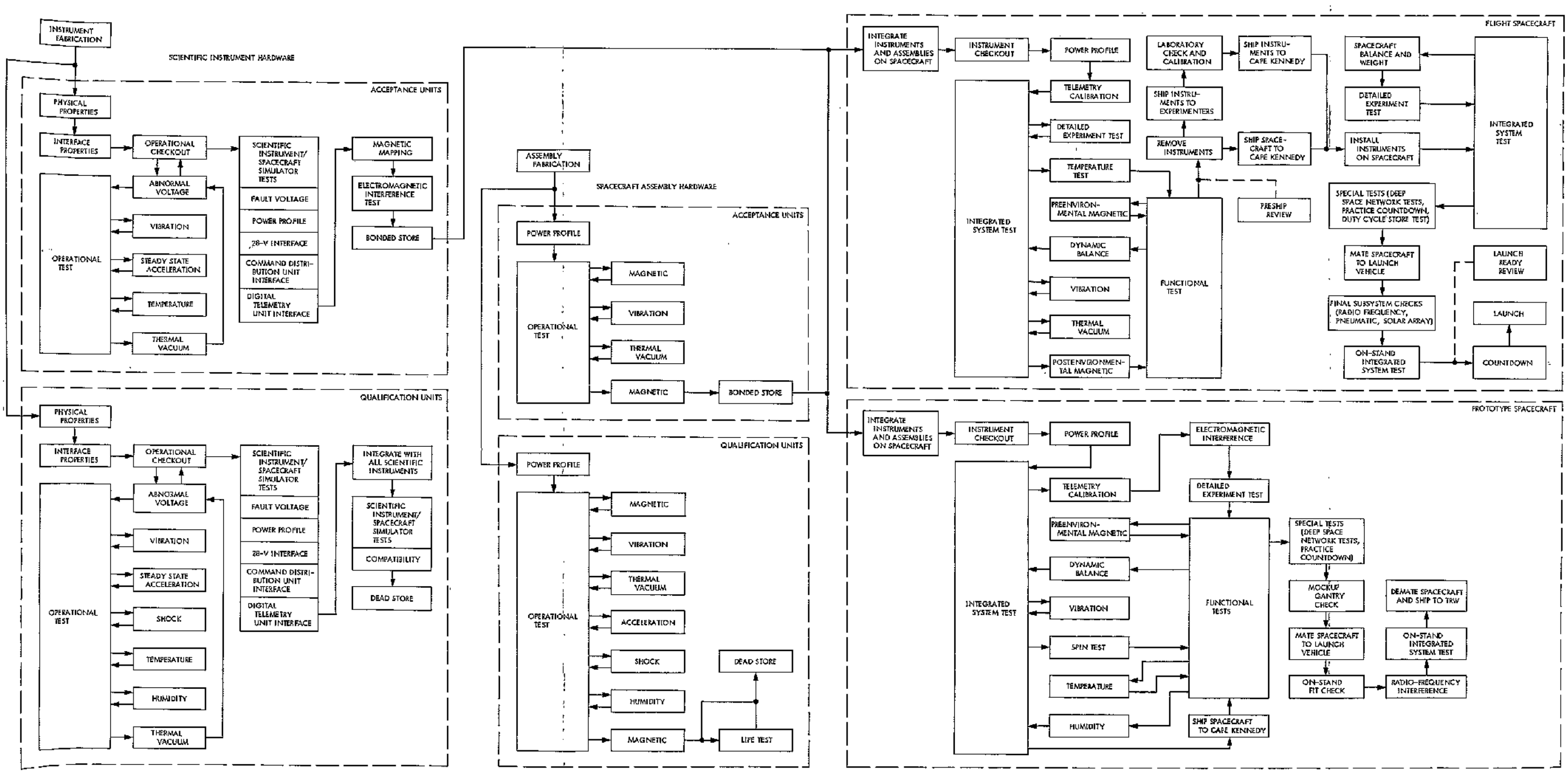



Fig. 42. Pioneer VII general test program



FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

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Table 16. *Pioneer VII* tests

| Type of test | Remarks |
|---|---|
| Weekly checkout of FPAC *Pioneer* flight programs | |
| Telemetry and command test | |
| DSS 51/FPAC acceptance test | |
| DSS 12/SFOF acceptance test | |
| DSS 12 daily operations test | |
| DSS 42/SFOF acceptance test | |
| DSS 51 daily operations test | |
| DSS 12 daily operations test | - |
| DSS 42/SFOF/FPAC acceptance test | Not too good by FPAC; program and procedures poor |
| DSS 51 daily operations test | |
| DSS 42 daily operations test | |
| DSS 51/SFOF acceptance test | |
| DSS 51/SFOF acceptance test | |
| SFOF (FPAC) acceptance test (internal) | |
| DSS 12/SFOF integration test | |
| DSS 42/SFOF integration test | |
| DSS 12 program checkout with SFOF | |
| DSS 51/SFOF integration test | |
| DSS 12/SFOF integration test | |
| AFETR/SFOF/DSS 51 integration test | AFETR portion OK; severe DPS problem forced termination 2 h early |
| DSS 71/SFOF integration test | |
| DSS 12 daily operations integration test | |
| Operational readiness test 1 (AFETR/DSN/ARC/STL/Stanford) | |
| Operational readiness test 2 (AFETR/DSN/ARC/STL/Stanford) | |
| Operational readiness test 3 (AFETR/DSN/ARC/STL/Stanford) | |

*1. Telemetry and command system acceptance tests.* The purpose of these tests has been to evaluate the performance of men and equipment associated with the telemetry data and command systems. These tests were conducted at Deep Space Stations 12, 42, and 51.

*2. Subsystem acceptance tests.* The purpose of these tests has been to demonstrate to the SFOD, operating from the SFOF, the satisfactory performance of equipment and personnel of each element of *Pioneer* operations. The following tests comprise this class of test:

DSIF 12: Daily operations tests and type II orientation tests.

DSIF 42: Daily operations tests.

DSIF 51: First acquisition test. This test involved station performance during the initial pass of the spacecraft, including critical activities of first acquisition.

SFOF: Tests by FPAC, SPAC, and SSAC.

*3. Integration tests.* The purpose of these tests has been to familiarize space flight operations personnel with all phases of *Pioneer* procedures and intercommunications. Actual operation of the *Pioneer* mission was performed in the exercise of all elements. Deep Space Stations 12, 42, and 51 repeated the subsystem acceptance tests listed above.

*4. AFETR integration test 1.* The first composite readiness test was held as scheduled on July 29, 1966. All personnel were at their stations and ready to go at launch minus 4 h. Except for two events the entire simulation was flawless. The first anomaly was that DSS 71 was slow in sending frequency reports to the Project and completely missed a report at $L - 85$ min. The communication between the Project and TDA on handling and interpreting these frequencies could be improved.

The other unplanned event was that the communications organization switched lines between DSS 51 data line and simulated metric data line causing the simulated data to go to FPAC and DSS 51 slew data to go to the 7044 computer. When this was discovered, the lines were changed, and the proper data went to the right areas. However, the command decoder had to hold up on calculating an orbit at $L + 1$ h until enough data was accumulated in the system to calculate an orbit. The sequence of events was picked up at $L + 2$ h and continued uninterrupted.

The W computer string operating out of the FPAC area was used for the first time as the prime computer. Except for a few short breakdowns, the W string operated satisfactorily.

*5. AFETR integration test 2.* The AFETR integration test was held as scheduled on July 26, 1966. However, the FPAC group reported some minor problems due to the lack of headsets available. The minus count was picked up at $L - 30$ min. Communication with DSS 71 was found to be impossible as a result of the improper hookup of network communications to Cape Kennedy.

Simulated launch occurred as scheduled, and FPAC supported the launch according to the sequence of events until $L + 1$ h. At that time the only 7094 computer scheduled for this test developed internal conditions so severe that it was not able to communicate with the external world for over an hour.

By the time the computer was recovered, FPAC had run out of predicts to DSS 51 and DSS 42 because the OD group was unable to calculate an orbit for TDA to generate predicts at $L + 1$ h 40 min. However, an orbit on a fictitious epoch time was tried which was later supplied by the trajectory group. The sequence of events was again picked up at $L + 2$ h 40 min. The pseudo-residual program seemed to be working properly.

*6. Operational readiness tests.* The purpose of these tests has been to demonstrate that all personnel and equipment participating in the flight operations of the spacecraft were prepared to support the mission. Every unit was activated for the tests. The three tests were developed so as to reflect sequential improvement, thereby insuring maximum operational readiness.

*7. Conclusion.* All testing proved the operational readiness, within current commitments and time constraints, of all elements, to support the *Pioneer VII* mission. The DSN manager provided the Project manager with a real-time operational readiness evaluation at $T - 5$ days so as to confirm that all systems were prepared to go.

### D. Pioneer/S-Band and Compatibility

These tests were conducted at PAFB to verify the compatibility of the AFETR range user equipment and its capability to support the *Pioneer* S-band telemetry requirements. The primary test objective was to simulate the *Pioneer* transmitted data, receive, translate and record it with the AFETR telemetry system and evaluate the capability of the range user equipment to recover this data. These tests successfully demonstrated that the AFETR equipment and range user equipment planned for the *Pioneer* S-band telemetry requirements were compatible.



## V. *Pioneer VII* TDS Flight Support

### A. Near-Earth Phase Support

The TDA near-earth support for *Pioneer VII* was provided by selected resources of the AFETR, GSFC/MSFN, and DSN. A review of activities from prelaunch through the end of the nominal mission is summarized herein.

The *Pioneer* spacecraft was launched from AFETR into the ecliptic using the improved thrust-augmented *Delta* launch vehicle. The spacecraft spin axis was oriented perpendicular to the ecliptic so that scientific instruments, mounted perpendicular to the spin axis of the spin-stabilized spacecraft, were able to scan 360 deg of the ecliptic.

After injection into orbit, tracking and data acquisition was accomplished by the DSN throughout the duration of the deep space phase of the mission.

*1. Prelaunch.* The prelaunch activities comprised the final checkout phase of *Pioneer VII* in preparation for the countdown-to-launch operation. The prelaunch activity phase was started when the spacecraft was received at Cape Kennedy and terminated with the countdown phase on August 17, 1966.

An important phase of the prelaunch activities involved the prototype spacecraft in trial runs, evaluations, and special tests. This approach provided maximum preparedness for the flight spacecraft without exposing it to unproven or hazardous conditions and resulted in the application of proven equipment and tested checkout procedures during actual launch operations with the flight spacecraft.

The test program for the flight spacecraft was somewhat similar to that for the prototype spacecraft. One difference between prototype and flight spacecraft activities related to the scientific instruments. The prototype spacecraft had been delivered to Cape Kennedy as an integrated system with all six scientific instruments on board. In contrast, the scientific instruments for the

flight spacecraft, except the Stanford instrument, had been returned to the laboratories of the experimenters for final calibration and checking before delivery to Cape Kennedy. It was necessary, therefore, that these instruments be reintegrated into the flight spacecraft and tested as a system. This activity occurred during the first week of August 1966. Also, during this week, the TWTs and TWT converters of the flight spacecraft were temporarily replaced by the units from the prototype spacecraft to allow inspection of the former for a high-voltage breakdown (a problem encountered on another unit due to faulty potting) and then were reinstalled on the flight spacecraft about two weeks later when found to be in satisfactory condition. In addition, a malfunction (nonstandard bit rate) in the digital tememetry unit required a replacement unit. The malfunction was readily corrected, and the flight unit was reinstalled on the flight spacecraft within one week. The MIT plasma detector was replaced by the spare unit because of a possible intermittent arcing problem. The weight and balance checks proved the flight spacecraft to be within specification values. The final values of the mass properties are given in Table 17.

During early July and August, special tests, training, and practice runs for different phases of the countdown were made with the flight spacecraft. During the first half of the month, numerous round-the-clock duty-cycle store tests were conducted. Deep Space Station training exercises and detailed experiment tests were also performed.

Despite fit checks with the prototype spacecraft, certain insignificant intolerances between the launch vehicle interstage structure and the flight spacecraft were discovered during mating of the spacecraft and the third stage. The situation was corrected and the activity completed by the launch date.

During the on-stand integrated system test, which was the last system check prior to launch countdown, minor defects in electrical ground support and test equipment were found and rectified. The overall system of the spacecraft and launch complex was then ready for the launch countdown.

To insure tracking, data acquisition, and flight control during powered and free flight, training exercises and tests were conducted with the various launch and flight support groups. Personnel were indoctrinated, equipment was checked, and operation procedures for normal

**Table 17. Weight and mass properties of *Pioneer VII***

| Component | Weight, lb | |
|---|---|---|
| Structure | | 19.84 |
| Platform | 7.01 | |
| Booms and associated components | 4.38 | |
| Interstage | 1.17 | |
| Solar array support | 2.96 | |
| Other | 4.32 | |
| Thermal control | | 6.80 |
| Louvers, structure, actuators | 2.12 | |
| Insulation | 4.68 | |
| Electric power | | 33.58 |
| Solar array | 13.98 | |
| Battery | 2.19 | |
| Equipment converters | 3.02 | |
| TWT converters | 4.52 | |
| Cabling and connectors | 9.87 | |
| Orientation | | 7.14 |
| Sun sensors | 0.86 | |
| Pneumatic assembly | 3.97 | |
| Gas | 0.87 | |
| Electronics | 0.98 | |
| Wobble damper | 0.46 | |
| Communication | | 14.35 |
| Antenna (spacecraft) | 2.01 | |
| Transmitter driver | 1.31 | |
| TWT | 1.89 | |
| Receivers | 6.14 | |
| Other | 3.00 | |
| Command | | 10.72 |
| Decoders | 5 60 | |
| Command distribution unit | 5.12 | |
| Data handling | | 10.65 |
| Digital telemetry unit | 8.57 | |
| Signal conditioner | 1.73 | |
| Data storage unit | 0.35 | |
| Balance weight | | 0.72 |
| Total weight of spacecraft subsystems | | 103.80 |
| Scientific instruments | | 34.11 |
| Electronics and sensors | 32.15 | |
| Antenna | 1.96 | |
| Total weight | | 137.91 |
| | Mass properties | |
| | Stowed | Deployed |
| Roll moment of inertia, lb-in.$^2$ | 23,621 | 43,509 |
| Pitch moment of inertia, lb-in.$^2$ | 30,383 | 32,115 |
| Inertia ratio | 0.76 | 1.32 |
| Center of mass, in. from separation plane | 14.66 | 13.14 |

and emergency situations were tested thoroughly. Thus the readiness of the various domestic and overseas stations, the worldwide communications networks, and the launch and flight procedures were thoroughly evaluated.

The training exercises were conducted in three different phases. The first was the training of personnel and checking of equipment and procedures at individual stations. The second was the operation of a remote station in conjunction with the mission control center at JPL or Cape Kennedy to evaluate and correct any interface deficiencies. The third was the series of operational readiness tests. The entire system and personnel that would be operational from the launch countdown through the cruise mode of flight participated in these tests. The operational readiness tests concentrated on the sequence of events and procedures covering the time period from 4 h before launch until completion of orientation about 44 h after launch. Tracking stations were supplied with spacecraft trajectory predictions so that they could generate pseudo tracking data to exercise the tracking data handling system. Also, the tracking stations were supplied with telemetry data prerecorded on tape to simulate spacecraft and instrument behaviors and to rehearse the ground operational system and personnel.

Upon satisfactory completion of the on-stand integrated system test and the third operational readiness test, a launch readiness review meeting was held with representatives from all responsible agencies.

The spacecraft was reported to be in a satisfactory condition for launch. The scientific instruments removed at the contractor's plant before the spacecraft was shipped to Cape Kennedy had been successfully reintegrated. All qualification and acceptance tests had been completed, and all failure reports had been disposed satisfactorily under the cognizance of the failure review board. The spacecraft had completed many hours of failure-free operation. The TWT and TWT converter high-voltage breakdown, which had been encountered on *Pioneer VI*, was no longer considered a potential problem. The new potting design had been tested for 800 h of failure-free operation in thermal vacuum. The spacecraft had logged hundreds of hours of operation and testing, including a two-week continuous test run, before mating with the launch vehicle.

2. ***Countdown.*** On August 15, 1966, the launch countdown was initiated as planned. The tasks in the countdown for the spacecraft and instruments are described below:

(1) Task I—preparation for task II. The spacecraft and electrical ground support equipment were prepared for the countdown operation. The electrical ground support equipment was checked and turned on for the required warmup period.

(2) Task II—spacecraft and instrument functional checks. The launch readiness of the spacecraft and the instruments was evaluated. RF checks were made with both spacecraft receivers. All instruments were turned on and commanded to various operating modes. The spacecraft was commanded into all the different formats, modes, and bit rates. The flight battery was installed as the last step.

(3) Task III—final pneumatic pressurization. The orientation pneumatic subsystem of the spacecraft was pressurized for the last time, and a final gross system check was made.

(4) Task IV—ordnance installation and checks. The resistance of the ordnance devices and their associated firing cables was measured and compared with previous resistance measurements.

(5) Task V—final preparations. This task completed preparations and secured the spacecraft. All protective covers were removed, the final configuration was checked, and a visual inspection was made. The spacecraft was ready for fairing installation when this task was completed.

(6) Task VI—umbilical and RF checks. This task included a continuity check of the umbilical cables, connection of umbilical cables to the spacecraft, adjustment of lanyard length, and visual inspection.

The AFETR count was started at 0805. Three holds were encountered during the countdown: one at 0 − 95 min, a 53-min built-in hold (BIH); one at 0 − 12 min, a 5-min BIH; and one at 0 − 5 min, a 2-min *Pioneer* hold. The count proceeded smoothly after the 2-min hold to liftoff, with first motion occurring at 1520:17 GMT. Range safety experienced no malfunctions or discrepancies. The overall AFETR support was very good and the *Pioneer* spacecraft was put into a near-nominal heliocentric orbit.

At 0 − 48 min, the readings of the S-band center frequency were 2292.017 MHz. AFETR was reading 2292.037 MHz at the Telemetry 2 station. At

0 − 23 min, AFETR and JPL/AFETR were both reading 2292.017 MHz.

The difference in readings was apparently caused by the fact that there is a 20-kHz difference in the S-band frequency between the two-way lock mode used by NASA/DSIF facilities and the one-way mode used during the launch period. AFETR had no prior knowledge of the two modes nor of the frequency drop when changing modes.

At 0 − 20 min, the S-band antenna on RIS *Sword Knot* became unstable when switched out of the standby mode. Instability in the antenna system was recognized by its wandering from the directed position. The problem was isolated to the pitch and roll circuits. These circuits were locked out, and the system became stable. Since it was felt that acquisition could still be accomplished, the system was declared operational and data was successfully received in this mode of operation.

This intermittent oscillation remained a problem. Engineers were sent aboard the *Sword Knot* to determine the exact cause of the oscillation and initiate corrective action.

At 0 − 15 min, a power failure at Grand Bahama caused loss of the troposphere communications system. This loss affected only AFETR voice communications nets. When the failure occurred, AFETR switched affected communications nets to the subcable. To accomplish this switch, one *Pioneer* item (doppler data from Antigua) had to be switched from subcable to SSB. This switch is permitted, and the SRO gave notice that the switch had been made. At no time did AFETR call a hold, as secondary communication links were established by 0 − 9 min. However, at 0 − 5 min, a hold was called to evaluate the effect of the communication switch on the mission. The count was picked up again at 0 − 3 min.

The loss of troposphere communications was caused by a diode failure in the automatic voltage control unit. After replacement of the diode, the power and tropo were brought back up. The total outage time was 18 min.

*3. Liftoff.* The powered flight phase for *Pioneer VII* was considered to extend from liftoff on August 17, 1966, at 1520:17.3 through separation of the third-stage motor from the spacecraft. During this period, primary control of the mission was transferred from the mission control center at Building AE to the *Pioneer* mission support area at the SFOF. Other activities during this period relate primarily to tracking and telemetry acquisition; these are discussed in Section VI as part of the performance evaluation of the various elements.

Since no instruments were required to be on during the launch phase, the spacecraft was launched with the telemetry system in an engineering data format and a data rate of 64 bits/s. The moderately low data bit rate was selected to increase the probability of obtaining good diagnostic data in the event the TWT failed to turn on automatically after injection or difficulties were encountered because of spacecraft orientation during initial acquisition by DSS 51.

The AFETR safety charts showed the vehicle to be well within the 3-sigma limits during plotted flight. Vertical plane charts showed actual plot to be about 0.5 sigma high of predicted nominal XZ but about 1 sigma low of predicted nominal YZ from 25 seconds.

A nominal parking orbit was achieved, and four AFETR tracking stations, Pretoria, Antigua, Ascension, and RIS *Sword Knot*, tracked the second stage. The orbit determination (OD) group computation of the parking orbit, which started at $L + 35$ min, served as a backup computation to the prime computation made by AFETR. The backup computation was completed at $L + 1$ h 20 min.

Transfer orbit injection occurred at 1545:38.626. DSS 51 (Johannesburg) did not start sending acceptable two-way doppler data until 1558:24, which was 9 min after its nominal rise time. Good two-way doppler was continuously received every 10 s until 1602 (23 points), at which time DSS 51 lost two-way lock. Station 51 acquired two-way lock again at 1611 and transmitted good two-way doppler data every 10 s until 1613 (9 points) at which time DSS 51 lost two-way lock.

The angle data of DSS 51 received from 1558:24 to 1613 (2 points every 10 s) was good angle data with no discontinuity from loss of data. However, at 1613, the DSS 51 tracking antenna reached its "pre limit" (an angular setting, either in the hour angle or declination direction, such that angular measurements smaller than this setting causes the tracking antenna to stop auto tracking), and all angular data received after this time was bad. The next time good angle or doppler data from a tracking station was received was at 1644, which was the time DSS 42 acquired two-way lock.

The OD group was given the computer at $L + 1$ h (1620) to begin computing its PROR orbit. However, before the OD group could proceed with its computations, the AFETR backup parking orbit had to be cleared from the prime computer (W string) and restarted on the backup computer (X or Y string).

The first attempt by OD to compute the PROR orbit was started with DSS 51 tracking data only. The number of indicated good data points consisted of 32 points of two-way doppler, 102 declination points, and 102 hour angle points. After three iterations on the data it was clear that the orbit determination program could not fit the data properly. A decision was made to fit to the angle data only since there was only 5 min (32 points) of two-way doppler available and it was apparent that the orbit determination program could not fit to both the angle and doppler data. After fitting to the angle data only, the orbit that was computed did not fit smoothly over the angle data, and it deviated excessively from the nominal orbit; a decision was made to wait until DSS 42 (Tidbinbilla) data accumulated before determining the PROR orbit.

An orbit was computed on the fourth iteration by fitting to the two-way doppler from Stations 51 and 42 and the good angle data from both stations. A closer examination of the PROR orbit revealed that simulated *Pioneer VII* angle tracking data from Stations 51 and 42 of a previous test was being used by the single-precision orbit determination program to compute the orbit. In the first phase of the PROR orbit, where only Station 51 data was available, the 42 points of simulated angle data were enough to influence the fit so that a preliminary orbit from the combination of doppler and angle data or angle data only could not be computed.

In the second phase of the PROR orbit there was enough good two-way doppler and angle data accumulated in the data file from Stations 51 and 42 so that the simulated angle data was detected in the first iteration of the orbit computation and deleted in the subsequent orbit computations.

After the simulated angle data was discovered in the PROR orbit, all the orbit determinations shifted to the backup data retrieval mode of using the data from cards punched by the IBM 047. This procedure of handling the real-time tracking data eliminated the problem of getting simulated tracking mixed with the real-time tracking data. The Day 230 orbit computation used the 047 cards because the tracking data was not available on magnetic tape.

The real-time tracking data from Stations 51 and 42 was simultaneously transmitted to JPL–SFOF and AFETR, Cape Kennedy. AFETR computed an orbit with this Deep Space Station tracking data.

### B. Deep Space Phase Support

The DSN, as part of the TDS for a flight project, is normally assigned to support the deep space phase of each mission. Thus far, responsibility for providing TDS support from liftoff until the end of the mission has been assigned to the JPL Office of Tracking and Data Acquisition. A TDS Manager, appointed by the Office of Tracking and Data Acquisition for each flight project, works with the JPL technical staff at AFETR to coordinate the support of AFETR, MSFN, and NASCOM with certain elements of the DSN needed for the near-earth phase support. A DSN manager and DSN project engineer, together with appropriate personnel from the DSIF, GCF, and SFOF, form a design team for the planning and operational phases of flight support. A typical functional organization chart for operations is shown in Fig. 43.

Owing to the excellent performance of the *Pioneer VI* spacecraft and the larger-than-anticipated amount of scientific data obtained during the mission, the DSN tracking and data acquisition support requirements and commitments were increased for the *Pioneer VII* mission.

The Pioneer, Echo, Tidbinbilla, and Johannesburg stations, equipped with *Pioneer* ground operational equipment (GOE), were assigned to support the *Pioneer VII* mission. With GOE, the spacecraft can be commanded by the Deep Space Stations into desired modes of operation, bit rates, calibration, and maneuvers, and telemetry data can be sent during the pass to verify proper operation of the spacecraft and its scientific instruments. In addition, at these stations all telemetry data is recorded on magnetic tapes for future processing. These magnetic tapes are the only complete data record for a given pass.

The Pioneer and Echo stations were the prime stations committed for the nominal phase of the mission. The DSN support commitment for these stations was one tracking pass per day during the first four days after

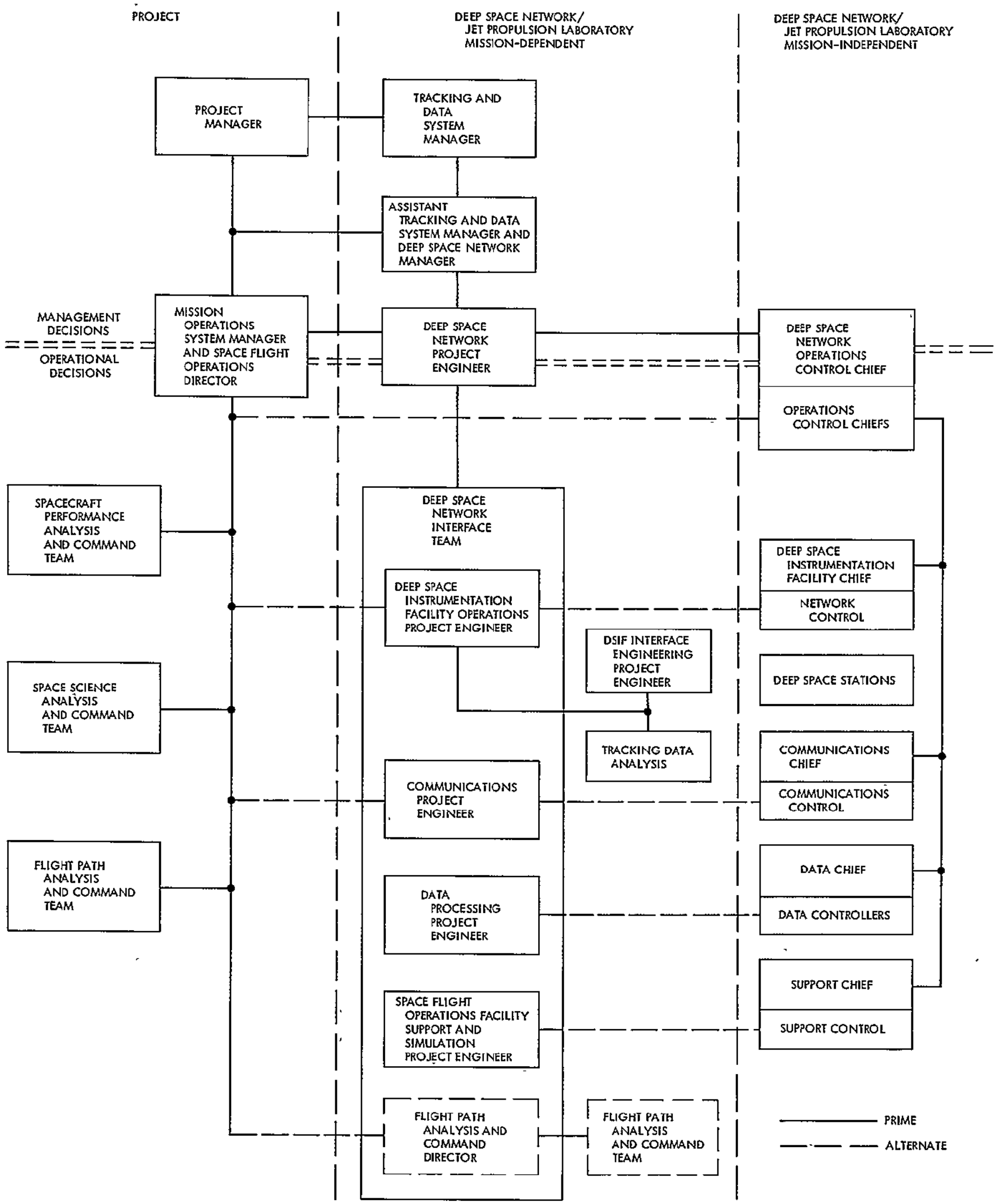


**Fig. 43. Typical functional organization for DSN mission support operations**

launch, one maximum pass[3] per day from five days until 30 days after launch, and two maximum passes per week thereafter. The Tidbinbilla station was committed for one tracking pass per day during the first four days after launch, and one maximum pass per day from five to 30 days after launch. The services of the Johannesburg station were planned on an "if available" basis. It was requested that, during the first four days after launch, the Johannesburg station should be available for one tracking pass each day.

In addition, the Woomera, Robledo, and Cebreros stations, without GOE, were to be available for support during the mission in a record mode only. The Ascension Island station, record mode only, was committed for one full tracking pass after launch. These stations can record the data in the same manner as the stations with GOE. However, data sampling and command transmission during such passes are not possible.

The Cape Kennedy station (DSS 71) was also committed for *Pioneer VII* mission support to make possible the spacecraft RF compatibility verification tests.

Beginning 31 days after launch, five maximum tracking passes per week were planned, using any combination of the following stations: Pioneer, Echo, Woomera, Tidbinbilla, Johannesburg, Robledo, and Cebreros. It was also planned, within the limits of DSN loading and station availability, to use any or all of the Deep Space Stations to provide a minimum average coverage of the equivalent of one pass per day beginning 31 days after launch until the end of the mission.

Since the main objective of the mission was to collect scientific data relative to interplanetary phenomena, special emphasis was given to support during solar flare activities. The DSN commitment stated that, in the event of class II or greater solar flare events, continuous tracking and data acquisition coverage would be provided.

It was also agreed that the *Pioneer VII* spacecraft tracking coverage from the stations equipped with 85-ft antennas would be terminated at the time when the 8-bits/s telemetry data was distorted by a bit error rate of $10^{-3}$ (one error in 1000 detected bits or 0.1% error) or larger, making further telemetry acquisition effort impractical. Telemetry data with a bit error rate of $10^{-2}$ would be acceptable to the *Pioneer* Project. If available error correction techniques would be applied, meaningful readout of measurements generated by the flight instruments would be possible.

[3]The length of a maximum tracking pass is defined by the duration of direct visibility of the spacecraft, limited only by the terrain and antenna hardware constraints.

It was also planned to provide tracking and data acquisition support from the Mars station after the phaseout of support by the 85-ft-antenna stations. This station, at the time the *Pioneer VII* commitments were made, was not fully completed and was not given an operational status. Therefore, this facility was made available on a "best effort" basis.

It was planned to have daily tracks available at DSS 14 for each *Pioneer* mission. Owing to single station capability limitations, the support ratio between the *Pioneer VI* and *VII* missions at DSS 14 was to be coordinated by the *Pioneer* Project for the best utilization of all spacecraft instruments.

Four full-duplex teletype circuits and one voice circuit between the SFOF and the Echo, Tidbinbilla, Johannesburg, and any other scheduled stations were assigned as part of the GCF *Pioneer VII* mission support, subject to circuit priorities. It was also planned to furnish, during launch operations, three full-duplex teletype and three voice circuits between the SFOF and the JPL communications center at Cape Kennedy and three full-duplex teletype and voice circuits between the SFOF and DSS 71.

The *Pioneer* mission support area in the SFOF was committed for the SFOD and his team to direct, during launch operations, all elements of space flight operations, SPAC, and SSAC functions. It was also planned that the FPAC team would perform all prelaunch and postlaunch computations necessary for orbit determination and predictions. The SFOF was committed to generate medium-accuracy orbits, based upon tracking data received from the Deep Space Stations; provide continuous data validation; and render any other services necessary to make a reliable spacecraft acquisition as soon as possible and have precision orbit data available to meet the required accuracies. A further commitment was to furnish the *Pioneer* Project the best possible telemetry data.

*1. DSN mission support.* To prepare for a successful *Pioneer VII* launch, FPAC tests, an SPAC/SSAC acceptance test, FPAC acceptance tests, SFOF integration tests, DSS/AFETR integration tests, and two operations readiness tests were performed from June 16 to August 15,

1966. After completion of these tests, DSN and tracking-data-system readiness reviews were conducted.

Prelaunch checkout and launch preparation of the spacecraft and its scientific instruments were conducted by *Pioneer* Project personnel at Building AN at the Cape Kennedy Air Force Station. During this period, performance and verification tests of the RF link between the spacecraft and DSS 71 were performed. DSS 71 contained mission-independent and mission-dependent equipment (*Pioneer* GOE) identical to that at standard Deep Space Stations.

During prelaunch countdown, DSS 71 received telemetry data from the spacecraft and continuously monitored the spacecraft communications subsystem performance and the compatibility of the subsystem with the DSN. The direction and status monitoring of the DSN was performed at the SFOF. Also, the performance of the spacecraft and its scientific instruments was analyzed at the SFOF from spacecraft telemetry data teletyped from DSS 71. These activities served as backup to similar tasks performed at Building AN.

*Pioneer VII* was launched at 1520:17 GMT on August 17, 1966. During the near-earth phase of the mission, the AFETR network metric-tracked the launch vehicle and received telemetry data from both the spacecraft and the launch vehicle. The spacecraft telemetry data was recorded on magnetic tape for later processing and analysis. The tracking data was teletyped immediately and continuously to the real-time computer facility at CKAFS, where the characteristics of the trajectory were calculated for predictions to be used for the initial DSN acquisition of the spacecraft S-band signal. Similar activities were performed at the SFOF, using the AFETR tracking data.

The MSFN collected metric tracking and telemetry data from the *Delta* second stage on C-band. The metric tracking data was obtained by three MSFN stations, the telemetry data by six. Two orbits were covered 200 min after launch.

DSS 71 tracked the spacecraft S-band signal and supplied telemetry information, using its GOE and telemetry command processor, to the *Pioneer* mission support area at the SFOF until 190 s after launch, at which time it lost lock. DSS 72 (Fig. 44) locked onto the S-band signal of *Pioneer VII* at 1540:15 GMT (30 s after station rise) and recorded it for over 7 min, at which time the spacecraft reached horizon.

The first lock at DSS 51 was established 47 min after launch, approximately 90 s after the 10-deg elevation angle was reached. DSS 51 was autotrack at 1549:40. The signal strength was $-133$ dBmW, and the S-band acquisition aid was utilized. Two-way lock was established at 61 min 50 s after launch at the same station, using the S-band cassegrain monopulse feed. The signal strength was approximately $-100$ dBmW.

**Fig. 44. Ascension Island Deep Space Station (DSS 72), with 30-ft antenna**

At 1621, the signal at DSS 51 dropped rapidly to −115 dBmW. Therefore, tracking was transferred to DSS 42 at 1625:30. This station locked up in a two-way mode 1 min 30 s later. At 1635, there was a momentary loss of lock on the downlink. The lock was again reestablished in 30 s. Tracking was transferred from DSS 42 back to DSS 51 1 h 41 min after launch. Since firm tracking and data acquisition of the *Pioneer VII* S-band signal had been established, the near-earth support phase of the mission was considered successfully completed.

During this phase, the SFOF provided all necessary services, functions, and equipment. The FPAC team made computations of the parking orbit, which was nominal. The SFOF-computed orbit, available 35 min after launch, was used as a backup to the AFETR-computed orbit. The deviation between the two orbits was within the required accuracy limits. The computation of the solar orbit started 1 h after launch, utilizing two-way tracking data from Stations 42 and 51. The first computed solar orbit, available approximately 2 h after launch, was used immediately to generate new predictions for the Deep Space Stations. Three more orbits were generated within 20 h after launch, utilizing two-way tracking data from the Johannesburg, Tidbinbilla and Pioneer stations. All four orbits were very similar and the fit to the available data was almost perfect.

The GCF supplied all necessary support prior to, during, and after the launch of *Pioneer VII*.

All committed tracking and data acquisition services were furnished to the *Pioneer* Project to make available almost continuous telemetry information with the lowest bit error rate, as well as the necessary two-way doppler tracking information required to update the orbit parameters and generate frequency predictions for the Deep Space Stations. Figure 45 summarizes the tracking and data acquisition support rendered by the DSN from the *Pioneer VII* launch until the eighth week of 1968. During the 6-month-long nominal mission, not only have the minimum requirements and commitments been met, but a considerable amount of additional support has also been furnished.

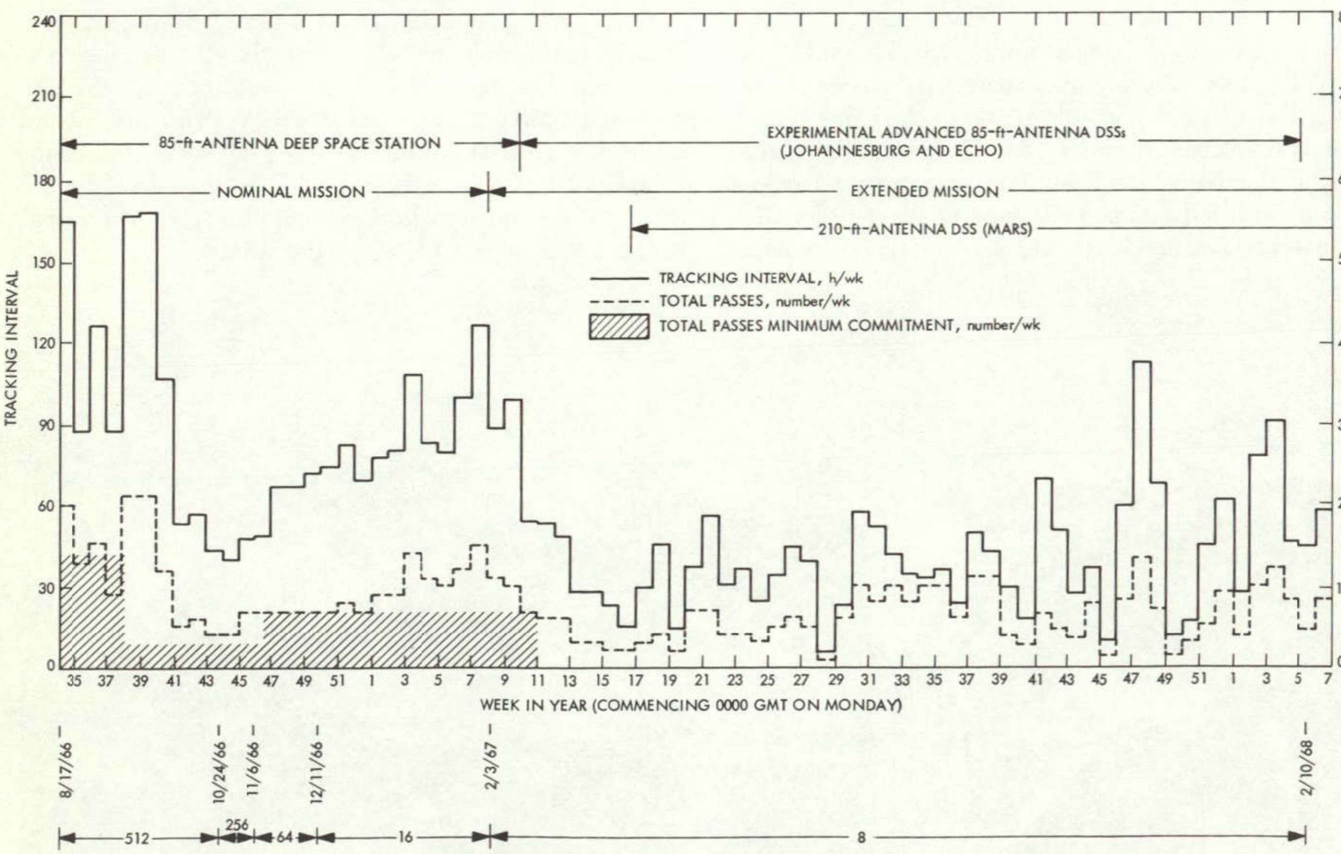


**Fig. 45. DSN operational support of *Pioneer VII* mission**

The fixed earth–sun line heliocentric trajectory of *Pioneer VII* is shown in Fig. 46. The time ticks drawn on the trajectory represent spacecraft position on the first day of each given month. The *Pioneer VII* telemetry threshold ranges are displayed for the standard and the experimental advanced 85-ft-antenna stations (Johannesburg and Echo), as well as for the 210-ft-antenna Mars station. The free-space attenuation scale can be used as a relative measure.

During the nominal mission, the principal TDA support was provided by the 85-ft-antenna stations equipped with the *Pioneer* GOE: Johannesburg, Goldstone, Echo, and Tidbinbilla. In addition, the Pioneer station also provided support utilizing the microwave link between the Pioneer and Echo stations and the multiple-mission support area at the Echo station. This configuration made possible the demodulation of the telemetry signals received by the *Pioneer* DSS S-band receiver with the *Pioneer* GOE located at the Echo station, thus expanding the usage of the only *Pioneer* GOE in the Goldstone DSCC.

This mode of operation was necessary to meet the *Pioneer* TDA support requirements and commitments without conflicting with the mission support of *Lunar Orbiter I* (launched August 10, 1966), provided by the Echo, Woomera, and Robledo stations. *Lunar Orbiter II* (launched November 6, 1966) and *Lunar Orbiter III* (launched February 5, 1967) missions were supported by the same stations. Therefore, the *Pioneer VII* support from the Goldstone DSCC between the *Lunar Orbiter* missions was provided by the Echo station; at other times, the Pioneer station was used. Though the *Surveyor II* launch on September 20, 1966, further increased the DSN load, any possible support conflicts were resolved without affecting the DSN support of the *Pioneer VII* mission.

During the first 10 days after launch, the Johannesburg, Tidbinbilla, and Pioneer stations furnished 100% coverage for the *Pioneer VII* mission. The Pioneer station sent the commands for the type II orientation maneuver during the second pass. These commands rotated the spacecraft about the sun–probe line and stopped it at that orientation which resulted in the greatest signal strength at earth. At this position, the spin axis was known to be normal to the plane of the earth, sun, and probe. During this maneuver, the spacecraft antenna radiation pattern was plotted, and the spacecraft spin axis was positioned to receive the greatest signal strength at the tracking stations around the earth.

From 11 to 33 days after launch, the DSN provided, on the average, two passes per day (the minimum commitment). To detect sun radiation anomalies, *Pioneer VII* traveled through the geomagnetospheric tail of the earth, starting 34 after launch. During this syzygy configuration, 100% tracking coverage was provided by the Echo, Woomera, and Cebreros stations. On October 1, the syzygy coverage of *Pioneer VII* was completed.

The telemetry data acquisition threshold of a 0.1% bit error rate was reached at the standard 85-ft-antenna stations on March 21, 1967. Prior to that date, the DSN initiated supporting research-and-technology efforts to improve the *Pioneer* telemetry threshold capabilities of the 85-ft-antenna network. This was the only way to further increase support capabilities without being forced to continue support using only the 210-ft antenna at the Mars station, which was already tracking *Pioneer VI*.

The first hardware modified to improve the telemetry detection threshold was tested at the Echo station during March. The 12-Hz S-band carrier tracking loop bandwidth was narrowed to 5 Hz and later to 3 Hz. In a receive, one-way mode only, the bit error rate was lowered from 0.1% to approximately 0.02%. Also, the system noise temperature of the Echo station was decreased. A specially designed waveguide bypass was installed that removed electrically the antenna diplexer and two waveguide switches from the microwave feed assembly. This change of the regular configuration decreased the system noise temperature by 11.5°K to approximately 29°K. Accordingly, the threshold improvement was 1.5 dB. These improvements made possible the Echo station support of the *Pioneer VII* mission during April. The telemetry bit error rate was within the acceptable limit.

During the first 2 weeks of May, the DSN supported the *Pioneer VII* mission from the Venus station, which has a system noise temperature of 30°K and a 3-Hz carrier tracking loop bandwidth. The linear polarized feedhorn of this station made possible a signal enhancement of about 3 dB. It should be noted that the *Pioneer* spacecraft transmit linearly polarized S-band signals, and the standard 85-ft-antenna stations have circularly polarized feedhorns. This configuration causes a 3-dB polarization loss at the standard stations, which have been optimized

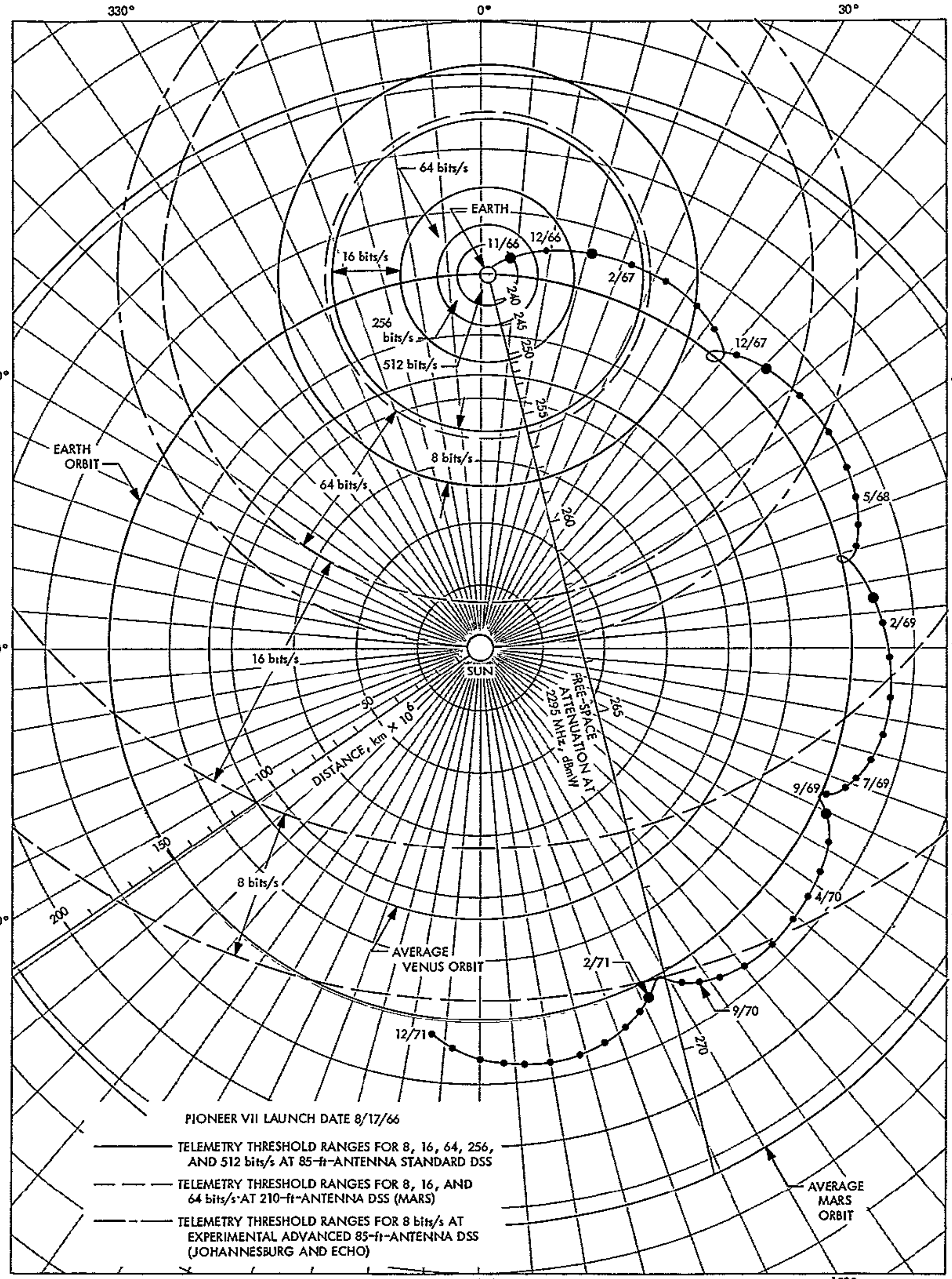


**Fig. 46. Fixed earth–sun line heliocentric trajectory of *Pioneer VII* and telemetry threshold ranges**

to track planetary spacecraft which operate with circularly polarized signals. The quoted threshold features of the Venus station made it possible to track *Pioneer VII* telemetry signals with no bit errors at an 8-bits/s rate.

During the second half of May, the *Pioneer VII* mission was supported by DSS 42. A 3-Hz tracking loop bandwidth capability had been incorporated, and a special waveguide modification had been made. In this configuration, the station was limited to receive-only operation.

The system noise temperature after the waveguide bypass installation was made was lowered to approximately 33.1°K; the standard noise temperature of this station is 42.5°K. The receiver threshold after both modifications was −177.5 dBmW; the receiver threshold in a standard configuration at the same station is approximately −173.5 dBmW. The overall system improvement due to both modifications, as derived using the parity error rate improvement, was equivalent to approximately 2.5 dB, of which 1.1 dB was attributed to reduced system temperature and the remainder to the 3-Hz tracking loop bandwidth.

Figure 47 shows the bit error rates obtained at DSS 42 during the latter part of May. The bit error rate for a normal pass was relatively constant for the middle of the pass, with a duration of approximately 4–6 h. The increase in error rate on either side of midpass was attributed to the noise contribution of the relatively large sidelobe sensitivity caused by damage to the antenna surface from hail storms. The antenna surface panels were replaced, and the bit error rate of the *Pioneer VII* telemetry subsequently improved, as shown in Fig. 48. The Mars station also provided support during the same period and obtained telemetry with bit rates of 64 and 16 bits/s and a very low bit error rate.

From July until the end of 1967, the *Pioneer VII* mission was supported mostly by the Johannesburg and Mars stations. During the launch activities at the Johannesburg station for the *Surveyor IV–VII* and *Lunar Orbiter V* missions, only the Mars station was used for *Pioneer VII* tracking and data acquisition support.

The desire for increased 85-ft-antenna station support for *Pioneer VII* resulted in the development of a polarizer for the Cassegrain feeds. The test data for an R&D

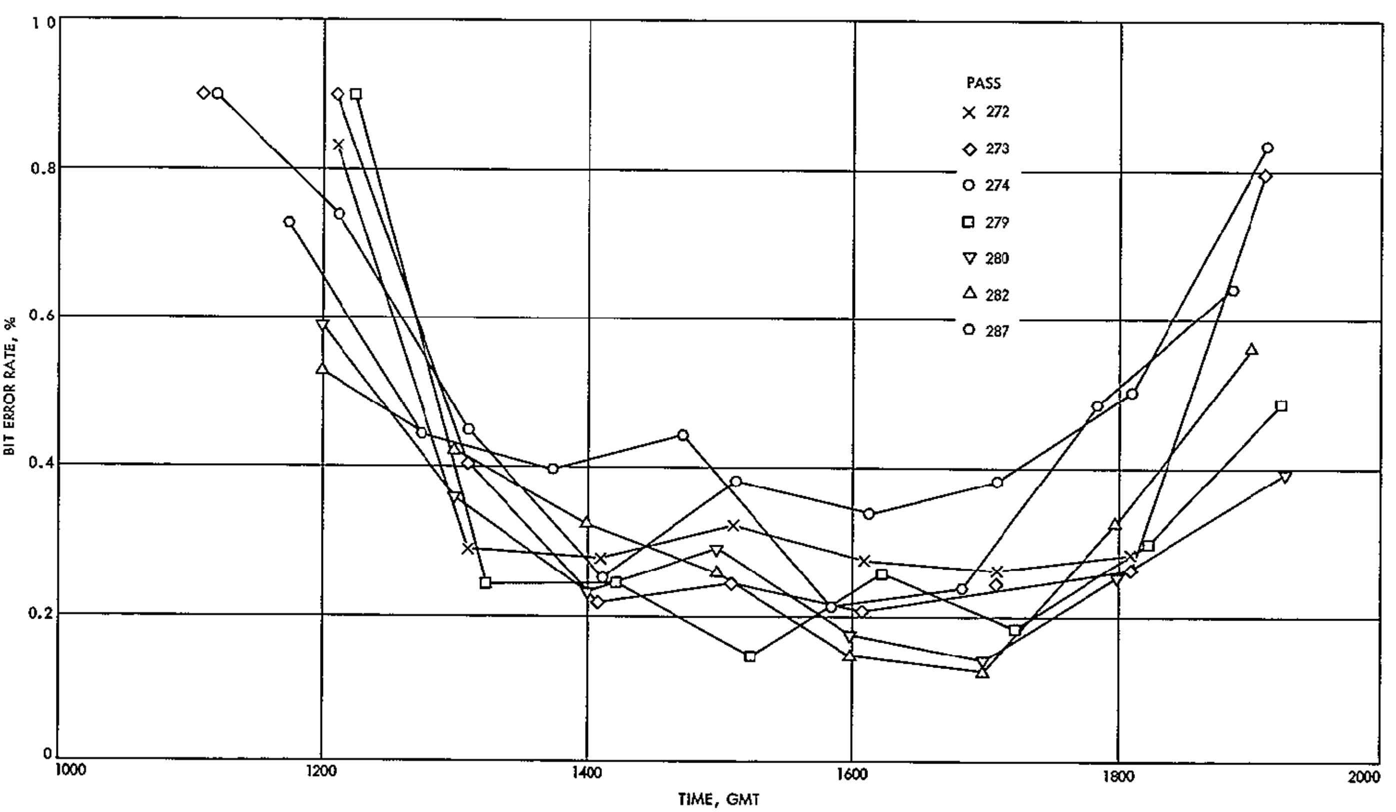


**Fig. 47. *Pioneer VII* telemetry bit error rates estimated at Johannesburg, DSS 51, May 15–31, 1967**

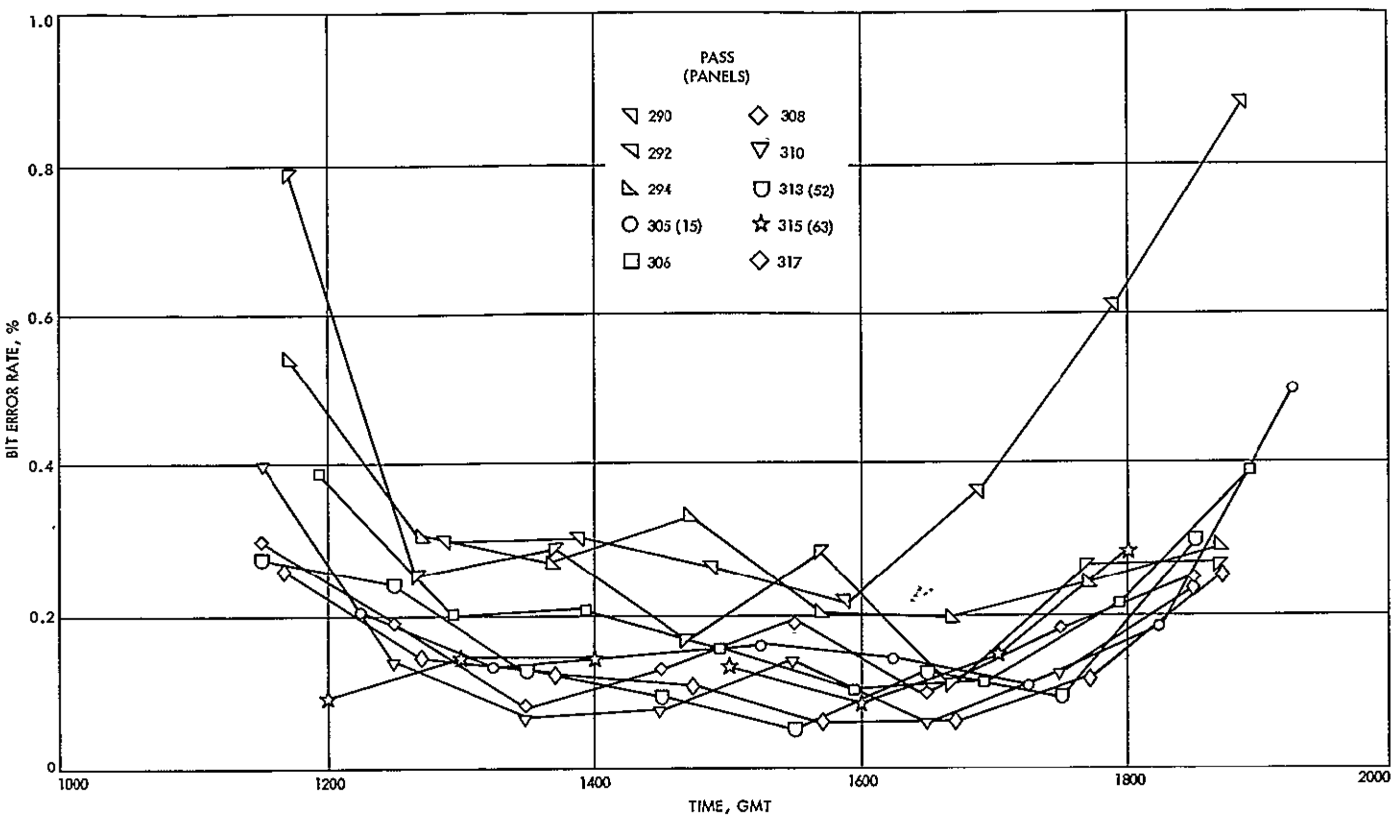


**Fig. 48. *Pioneer VII* telemetry bit error rates estimated at Johannesburg, DSS 51, June 1–30, 1967**

model indicated an approximate 3-dB improvement in signal level at both receive and transmit frequencies. This polarizer converted the standard circular feed to a linear feed. It was installed at the Johannesburg station during November 1967; its performance has been very satisfactory. An acceptable telemetry bit error rate was obtained until February 1968, at which time the spacecraft–earth range started to increase rapidly and *Pioneer VII* support by the experimental, advanced, 85-ft-antenna Johannesburg station was phased out. Since that time, the *Pioneer VII* mission has been supported, on a daily basis, by the Mars station, which has the capability to support the mission until its termination.

Thus, the *Pioneer VII* mission support by 85-ft-antenna stations was extended approximately 10 mo after the standard 85-ft-antenna network reached its telemetry threshold limit. This improvement made possible not only more TDA support for *Pioneer VI* at the Mars station, but also approximately 850 additional tracking hours of *Pioneer VII* mission support during a time when the DSN was supporting 12 other lunar and planetary missions.

The *Pioneer VII* telemetry system transmits scientific and engineering data at five discrete bit rates, ranging from 512 to 8 bits/s. During the first 18 mo after launch, *Pioneer VII* collected nearly $2.2 \times 10^9$ bits of telemetry information (72%, scientific information; 6%, engineering data; the rest, parity check and data identification). Throughout the flight, *Pioneer VII* operated primarily in the sampled real-time data transmission mode. All received data bits were recorded on an original master magnetic tape, and sampled telemetry data was transmitted in near-real-time, using teletype lines, to the SFOF and the *Pioneer* mission operations center at ARC. The *Pioneer* space flight operations team used this data for "quick-look" and operational control purposes.

The spacecraft duty-cycle storage mode[4] was used during the times the DSN was unable to furnish TDA

[4]In this mode the DSN is not receiving telemetry from the spacecraft, and the data is being stored on the spacecraft. It is the least desirable type of data retrieval method because the spacecraft memory unit has limited capacity and because a portion of the subsequent tracking period of a station must be reserved for playback. At the lowest bit rate, the time for playback can amount to 32 min.

support. Less than 0.1% of the total data was received in this mode.

Every phase of the mission thus far has been very successful; all flight instruments are still operating and continuously sending back excellent data on fields and particles. Based on its performance thus far, the estimated total lifetime of the *Pioneer VII* spacecraft is 5 yr. This nominal lifetime is used in DSN planning to estimate the future TDA support necessary for the mission.

The on-board S-band communications equipment (i.e., the channel 6 and channel 7 spacecraft receivers and the transmitter) is still performing within the tolerances of the given specifications. The performance characteristics of the S-band communications downlink, using the standard 85-ft-antenna stations, are plotted in Fig. 49. The S-band receiver input carrier level measurements at the Venus and Echo stations agree with the nominal values of the *Pioneer* communications systems design.

The approximate cutoff dates of the *Pioneer VII* telemetry bit rates are also very close to the predicted values. The measured average telemetry bit error rates are in the vicinity of the theoretical approximation.

2. ***Deep Space Instrumentation Facility.*** The following listing presents the sequence of problems and corrections (launch pass through pass 191) for Deep Space Stations:

*Prelaunch.*

At $T - 130$, DSS 51 experienced transmitter failure caused by a high-voltage rectifier insulation breakdown in the transmitter power supply. Corrective action was taken, and prior to launch time the transmitter was operative with sufficient power output for acquisition.

*Launch and pass 1.*

Launch was on August 17, 1966, at 1520 GMT.

DSS 51 lost lock twice during the first pass. The first time lock was lost when the station went SCM[5] without reducing spacecraft SPE[6] to zero. The second loss of lock was a result of prelimits on the antenna, a hot third-stage burn and a low trajectory, causing the spacecraft to dip over the horizon sooner and farther than expected.

[5]S-band Cassegrain monopulse.
[6]Static phase error.

*Pass 2.*

DSS 42 reported no problems.

DSS 51 computer failed to change the day at 2400. A standard restart procedure removed the anomaly. Program fault suspected and under investigation. During the posttrack calibrations, the antenna brakes seized and locked, preventing angle error checks and AGC calibrations.

DSS 11 performed type II orientation, sending 191 commands. Transmitter body overcurrent indicator came on and transmitter turned off. It was turned back on 5 s later with no recurrence of the problem during the pass.

*Pass 3.*

DSS 42 GOE prime demodulator failed during pretrack tests. A spare was installed and operated satisfactorily throughout track.

DSS 51 computer again failed to change day at 2400. The program was reloaded and a standard restart procedure performed. The transmitter beam voltage tripped off during the pass. The transmitter was reset and was back on within 1 min. No further occurrence. After the station acquired two-way lock, uplink was lost, possibly due to late tuning by DSS 42. Frequency sweeping was begun, and spacecraft was reacquired two-way after 7 min.

Transmitter body overcurrent interlock again tripped, causing transmitter to turn off. Transmitter was turned back on with no indication of high body current.

*Pass 4.*

DSS 42 power supply relay stuck, resulting in failure in waveguide switch. Since the transmitter could not be switched from dummy load to SCM, it could not be turned on at the scheduled time. The problem was isolated and remedied in 5 min.

DSS 51 maser began to warm up. Station switched to paramp and began an investigation to determine cause of problem.

DSS 11 VCO counter printout contained three errors. The situation was corrected by readjusting the counter gain.

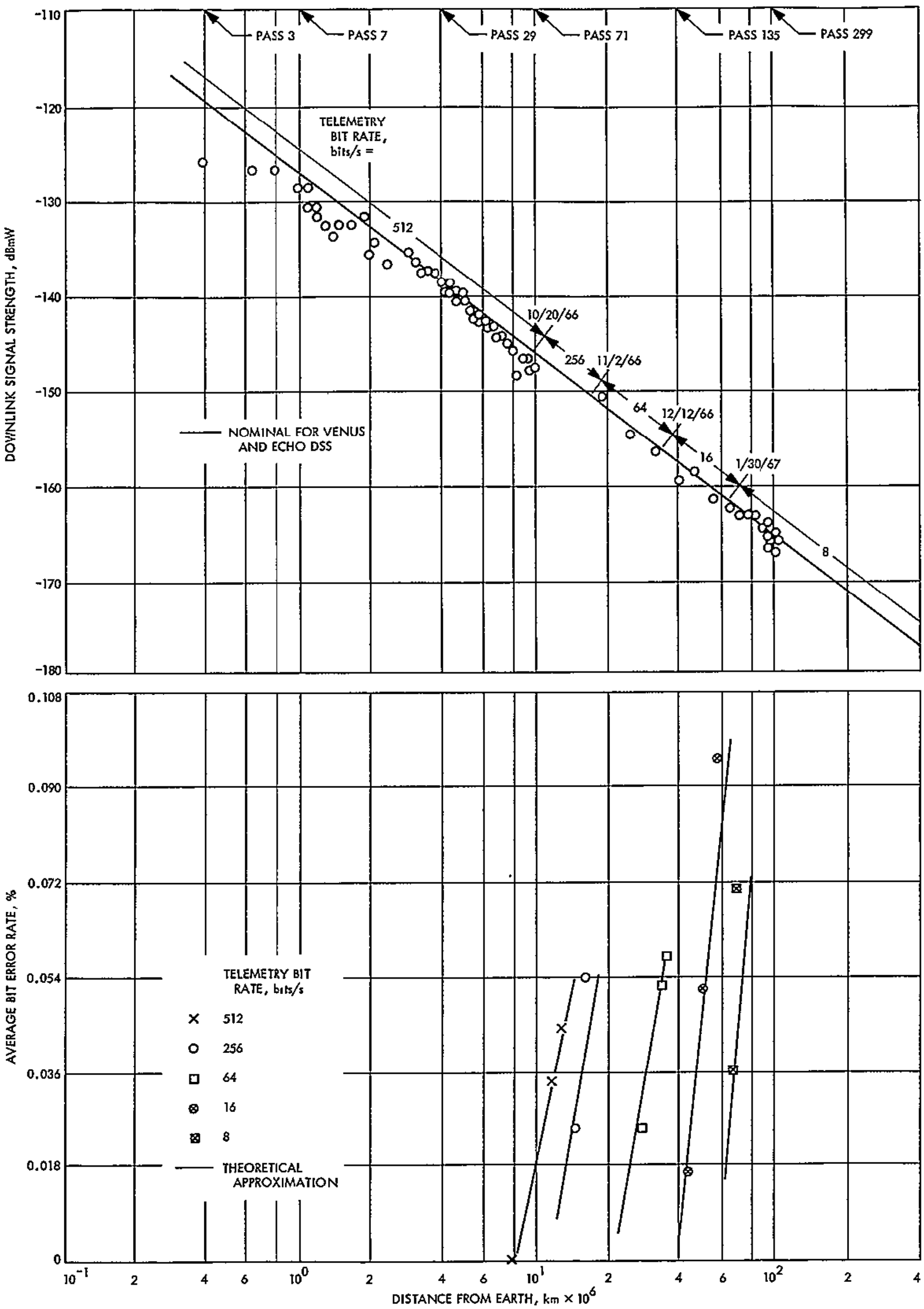


**Fig. 49. Performance characteristics of S-band communications downlink using standard 85-ft antenna**

*Pass 5.*

DSS 42 reported no problems.

DSS 51 continued operating on paramp.

DSS 11 reported no problems.

*Pass 6.*

DSS 42 reported no problems.

Because it had been instructed to return the monitor receivers to JPL, DSS 51 operated using abnormal command mode.

DSS 11 tracking data handling (TDH) teletype machine printed garbled messages. Machine was replaced. An error occurred in the TDH DEC readout.

*Pass 7.*

DSS 42 had a voltage regulator failure in the generator house. TDH punch 2 became inoperative due to fault between the reader and the preamble generator. Investigation was begun to find the specific fault.

DSS 11 DEC readout was oscillating at time of acquisition. Normal operation was achieved by adjusting the feedback loop. A printout error occurred in the TDH antenna HA angle.

DSS 51 had a 4-min power failure prior to pass. This was caused by a failure in a U bus voltage regulator. TDH punch 2 became inoperative due to a fault between the reader and the preamble generator.

*Pass 8.*

DSS 42 reported no problems.

DSS 51 FR 1400 recorder A overheated due to a faulty cooling fan. Fan was replaced after track.

DSS 12 had parity errors for 27 min. Trouble cleared up prior to discovery of its cause. Operation was switched to TDH punch 2 when a bad transmission distributor in punch 1 caused garbled output.

DSS 11 transmitter went off due to power output interlock. The transmitter had been calibrated for 100 W prior to acquisition, but during track was unable to obtain a sufficient power output to maintain the spacecraft AGC level at −122 dBmW. Net control authorized a spacecraft AGC level at −126 dBmW.

*Pass 9.*

DSS 42 reported no problems.

DSS 51 experienced periodic dropouts of channel 7 ground instrumentation on FR 1400 tape recorder. Bad tape suspected. Being unable to obtain the required spacecraft AGC level of −122 dBmW by adjusting transmitter power, station fixed power at 300 W for spacecraft AGC at −124 dBmW.

DSS 11/12 TDH punch 1 again failed due to a bad tape guide. Operation was switched to punch 2. Punch 2 failed because of a bad transmitter distributor; operation was switched back to punch 1 after tape guide was repaired.

*Pass 10.*

DSS 42 reported no problems.

DSS 51 transmitter tripped off; no apparent cause. Power was restored 4 min later. Personnel erroneously turned off transmitter 5 min early; however, DSS 11 acquired the spacecraft satisfactorily.

No tracking data was sent from DSS 11/12 in real-time due to misalignment of TDH brake arm. Data was sent after the track from an SDS 920 which had been programmed to monitor the TDH equipment and printout. Owing to operator error, 3.5 h of CEC data was not recorded because an individual amplifier was not turned on.

*Pass 11.*

Sorenson-regulated power supply to the maser failed. Switched to paramp until the maser was repaired. GOE 300-V power supply failed.

DSS 11/12 reported no problems.

*Pass 12.*

DSS 42 GOE computer buffer caused spurious interrupts to the computer. The B computer failed due to memory parity errors.

A bit error test with DSS 11/12 indicated an excessive bit error rate due to a bit error tester malfunction.

*Pass 13.*

DSS 42 reported no problems.

DSS 11/12 CEC recorder excitation lamp failed.

*Pass 14.*

*Pioneer VII* was not tracked during this pass.

*Pass 15.*

DSS 51 experienced hydraulic pressure failure at 0346 GMT owing to HA pump motor pressure line fracture at output flange. Failure occurred 14 min prior to scheduled end of trade (0400 GMT). Station was advised that efforts to reconfigure to SAA and continue track would not be necessary since DSS 11 would acquire before change could be completed. One min 6 s of data was lost between DSS 51 end of track and DSS 11 acquisition. Failure has been repaired.

*Pass 17.*

DSS 42 experienced antenna drive failure due to overload trip on HA regulated power supply. Before normal operation was reestablished, 2 s of data was lost.

*Pass 20.*

DSS 11 reported the FR-1400 recorder B inoperative due to noise on all recording channels.

*Pass 21.*

DSS 42 reported excessive doppler phase jitter due to a defective 1-MHz cable in the frequency and timing subsystem. Cable was replaced after 35 min of bad doppler was recorded.

DSS 11 reported antenna servo would not operate in autotrack mode, apparently due to incorrectly phased angle channels. Used spacecraft to rephase angle channels.

*Pass 22.*

DSS 42 reported intermittent excessive exciter jitter.

DSS 51 reported a faulty counter, causing TDH data synthesizer count to print all zeros.

*Pass 23.*

DSS 51 noted FR-1400 track 2 data (bit sync) was intermittent. Trouble caused by faulty frequency shift modulation record module which was replaced.

*Pass 24.*

DSS 51 reported IRIG channel 5 VCO frequency offset low. (This is the receiver in/out-of-lock channel.) Replaced VCO.

DSS 42 reported TDH VCO counter triggering incorrectly. Replacement of 20-MHz converter failed to remedy problem. Under investigation.

*Pass 29.*

DSS 12 reported erratic TDH HA readouts. Located cause in DIS and in cable carrying HA data to digital instrumentation subsystem. Temporary repair was made. Cable repaired subsequently. HA printout data was bad from 0258 to 0349 GMT.

*Pass 31.*

DSS 12 tracked on paramp as the maser was down for maintenance. The bit error rate was 0.273 until the paramp pump power was adjusted, thus reducing the bit error rate to 0.089.

*Pass 33.*

DSS 12 maser heated up during the pass and the station switched to the paramp. After breakdown of the Joule-Thompson circuit pump, the station returned to the maser.

*Pass 35.*

DSS 12 obtained no TDH doppler readouts as the doppler counter power supply had been turned off. The power supply was turned on and the doppler readouts began.

*Pass 36.*

DSS 41 transmitter tripped off once during pass for an undetermined cause.

DSS 61 experienced a card failure in the TDH. Switch S-4 on the test signal control caused receiver noise when placed in receiver position.

*Pass 41.*

DSS 51 had an increase in the bit error rate, possibly due to arcing in the diplexer. After 20 min, the problem disappeared with no recurrence.

*Pass 42.*

DSS 12 computer stopped. It was restarted and there was no further occurrence of the halting.

*Pass 43.*

DSS 51 noted no deviation of the carrier frequency from the FR-1400 wide-band frequency-modulated record electronics. A module was replaced.

*Pass 45.*

DSS 14 receiver lost lock due to the operator entering the wrong offsets into the antenna pointing system.

DSS 42 had a runaway antenna due to a bad integrator module. The unit was replaced.

*Pass 49.*

DSS 12 lost receiver lock due to antenna driving off signal source while on computer drive. Antenna went to aided track. Lost data for 60 s.

*Pass 72.*

DSS 51 acquisition delayed due to incorrect crystals in receiver. Crystals were changed and acquisition was made.

DSS 51 WBFM module faulty on recorder A. Module was replaced.

*Pass 74.*

DSS 12 transmitter lost lock due to blown fuse in heat exchanger. This caused a loss of lock in receiver. Loss of data for approximately 2 min.

*Pass 80.*

DSS 51 transmitter failed causing loss of lock. Transmitter was reset. Loss of data for 30 s.

*Pass 86.*

DSS 51 transmitter lost lock due to air leak in nonreturn valve to surge tank in heat exchanger. Nitrogen bottle connected and leak stopped. Loss of data for approximately 2 min.

DSS 11 exciter failed, causing loss of lock. UHF buffer amplifier repaired, and transmitter was returned to operation. Loss of data for 29 min.

*Pass 87.*

DSS 11 transmitter failure caused receiver to drop lock. This was due to loss of waveguide pressure. Loss of data for approximately 23 min.

*Pass 91.*

DSS 51 transmitter failure caused receiver to drop lock. Loss of data for 35 s.

*Pass 99.*

DSS 51 transmitter lost lock for no apparent reason. This caused a loss of receiver lock. Transmitter reacquired. Loss of data for 80 s.

DSS 12 had bad engineering data for 12 min because computer was erroneously switched to tape playback on time track.

*Pass 105.*

DSS 51 receiver dropped lock for no apparent reason. Reacquired 20 min later. Twenty-min reacquisition was due to servo operator using wrong predicts.

DSS 51. When tape was being changed on FR 1400, the reel would not tighten. New reel hub installed.

*Pass 106.*

DSS 51 receiver dropped lock due to fluctuations in DEC angle. DEC angle locked and tracking was normal. Loss of data for 30 s.

*Pass 111.*

DSS 51 transmitter dropped lock causing receiver to drop lock. Reacquired transmitter and receiver. Loss of data for 30 s.

*Pass 114.*

DSS 11 receiver failure in HA channel resulted in loss of drive to servo. Servo to aided track receiver reacquired. Loss of data for approximately 150 s.

*Pass 115.*

DSS 11/12 microwave line bad due to power supply at communications.

*Pass 117.*

DSS 51 time code bad in 910 computer. 920 computer on line.

*Pass 121.*

DSS 12, numerous glitches in receiver due to low transmitter power during threshold test.

*Pass 127.*

DSS 12, numerous glitches in receiver occurred during command transmissions.

*Pass 128.*

DSS 51 sample and hold signal not recorded because demod was in wide-bandwidth position.

*Pass 133.*

DSS 12 maser failure. Tracked on paramp and had high bit error rate count.

*Pass 135.*

DSS 12 receiver out of lock due to maser warmup. JT circuit adjusted. Approximately 1 h of data lost.

DSS 12 receiver out of lock due to loss of hydraulic power to servo. Power restored. Out of lock for 2 min.

*Pass 140.*

DSS 14 receiver lost lock due to failure in program for antenna pointing system. Program changed to mode 2. Out of lock for approximately 2 min.

*Pass 142.*

DSS 42 transmitter tripped due to focus magnet undercurrent. Loss of data for 2 min.

DSS 51 lost demod data. Found to be faulty cable.

DSS 12 transmitter final amplifier assembly producing no RF. Klystron replaced.

*Pass 145.*

DSS 51 FR 1400 recorder lost bit sync signal due to dirty head. Loss of lata for 25 min.

*Pass 151.*

DSS 11 loss of receiver lock apparently due to an increase in command modulation via microwave link. Readjusted to proper level. Out for 50 s.

*Pass 156.*

DSS 42 servo failure due to blown fuse. Necessary to turn off transmitter. Loss of data for approximately 13 min.

*Pass 157.*

DSS 51 lost receiver lock due to multicore cable plug failure. Intermittent loss of data throughout pass.

*Pass 159.*

DSS 51 numerous receiver glitches causing halt of commands. Problem isolated to faulty crystal.

*Pass 160.*

DSS 11 transmitter lost lock due to interlock problem. Out of lock for several min.

*Pass 161.*

DSS 12 antenna lost lock due to blown fuse in translator power supply. Lost 10 min of data.

*Pass 163.*

DSS 42 transmitter drive failed due to negative 15-V power supply. Lost 9 min of data.

*Pass 168.*

DSS 42 telemetry and command processor spacecraft AGC and spacecraft SPE readouts faulty. No loss of data.

*Pass 170.*

DSS 42 had high parity error rates throughout pass. Signal level was $-161.5$ dBmW, and bit rate was 16 bits/s, which is at near threshold. Also switched to 4.5-kHz telemetry bandwidth. This causes a degradation in the telemetry.

DSS 51 reported transmitter tripouts due to 400-Hz generator malfunction. The standby generator was brought on line to correct problem.

*Pass 177.*

DSS 51 had a transmitter tripout due to a high-voltage arc. This was attributed to heavy rains and electrical storms in the immediate area.

*Pass 178.*

DSS 42 and DSS 51 experienced random receiver glitches during transfer. The transfer rate was reduced to compensate.

*Pass 183.*

DSS 51 demodulator/sync out of lock for excessive amount of time. The signal at the demodulator/sync input was intermittently low. This anomaly cleared itself, and could not be reproduced during investigations hence.

*Pass 184.*

DSS 42 lost receiver lock due to program from digital instrumentation subsystem to antenna pointing system. This was due to an operator error which was corrected immediately.

*Pass 189.*

DSS 14 receiver lost lock due to antenna going to break position to check film level on pad 3 of hydrostatic bearing. The bearing problem is being investigated.

Table 18 details tracking support provided for *Pioneer VII* by the DSIF from the first pass through pass 191, covering a period of some six months.

3. ***Ground Communications Facility.*** The GCF provided all necessary support prior to, during, and after launch of *Pioneer VII*. There were no failures reported pertaining to the performance of the GCF during the launch phase of the *Pioneer VII* mission.

**Table 18. *Pioneer VII* DSS operations summary (all times are GMT)**

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 230 | 0425:20 | 1514:10 | 0425:20<br>0500.00<br>1402:08<br>1419:10 | 0500:00<br>1300:01 | 1300:01<br>1400.00<br>1422:10<br>1514:10 | −128.85 | 19 | Dec angle would not autotrack due to faulty servo iso-amp. Garbled tracking data received intermittently at SFOF throughout pass; cause unknown |
| | 42 | 229 | 1610:53 | 2112:00 | 1628:18<br>1631·59 | 1631:59<br>1930:00 | 1610:53<br>1625:00<br>1930:00<br>2012:00 | −116.6 | 10 | None |
| | 51 | 229/230 | 1548:22 | 0547 | 1548:23<br>1555:17<br>1625:00<br>1632:33 | 1555:17<br>1602:17<br>1602:17<br>1725:00<br>1930 00<br>0500.01 | 1632:33<br>1930:00<br>0500:01<br>0547:00 | −120.2 | 15 | 7 min 5 sec required to establish uplink SCM at 1610:52 GMT due largely to high XA deviation. Computer buffer alarm when sending 2nd of two commands; cause unknown. Day time on DIS science printout not updating; program reloaded. TXR tripping out; high voltage breakdown; TXR frozen at 1415 GMT with capability of radiating at 3 kW. Investigation pending |
| 2 | 11 | 231 | 0429:43 | 1537:15 | | 0515<br>0905<br>0906<br>1300.01 | 0429:43<br>0515:00 | −120.7 | 31 | Performed type II orientation. TXR failed at 0905:00 GMT due to body overcurrent; transmitter restored to normal within 5 s and remained normal throughout track; cause unknown. HSD tape broke on TDH punch 2 |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 42 | 230 | 1023 | 2140 | 1400<br>1419<br>1802<br>1809 | 1300<br>1400<br>1422<br>1800<br>1810<br>2000 | 1023<br>1300<br>2000<br>2141 | −128 | 6 | Bravo and engineering TTY lines not available until 1058 GMT; engineering and science perforations not running due to operator error |
| | 51 | 230/231 | 1826:11 | 0559:30 | | 2000:00<br>0515:00 | 1826:11<br>2000:00<br>0515:00<br>0559:30 | −130 | 12 | Day number not changed at 0000 GMT; cause unknown; program fault suspected. Standard restart corrected anomaly. Antenna brakes seized and failed to release preventing angle error checks and AGC calibrations. Cause unknown |
| 3 | 11 | 232 | 0425:32 | 1310.00 | 0425:32<br>0445:00 | 0445:00<br>1232:10<br>1236:19<br>1305.01 | 1305:01<br>1310.00 | −122.4 | 9 | TXR off due to body flow coolant interlock trip; no indication of high body current |
| | 42 | 231 | 1042 | 1921 | | 1042<br>1300<br>1300<br>1845:01<br>1853:19<br>1921 | | −115.95 | 7 | 1513:20 GMT preamble generator timing faulty. XA change not complete when transmitter turned off at 1845:01 GMT causing unsatisfactory transfer |
| | 51 | 231 | 1853:14 | 0447:00 | 2123:27<br>2128:45<br>2131:17<br>2114:03<br>2149:05<br>2203:25<br>2207:50<br>2217:54 | 1845:18<br>2109:04<br>2203:36<br>2207:45<br>2218:01<br>0445:01 | 1837:07<br>1845:18<br>0445:01<br>0447:00 | −119.7 | 12 | Special data point test executed this pass by SDA from 2109 to 2221 GMT; 4 data points taken |
| 4 | 42 | 232 | 1239:05 | 2000 | | 1305<br>1945:01 | 1240<br>1305<br>1945:01<br>2000 | −119.5 | 5 | Transfer from DSS 11 to DSS 42 delayed 5 min due to hung relay preventing switching TXR from dummy load to SCM. CEC traces lost between 1853 and 1917 GMT. Lamp replaced |
| | 51 | 232/233 | 1930 | 0500 | 2003:10<br>2006:14 | 1930<br>1945<br>1945<br>2003:10<br>2006:14<br>0445<br>0445<br>0500 | | −122.7 | 9 | Continuing maser warm up; reconfigured to paramp. Command transmitted late due to computer malfunction. Schedule time 2031 GMT. Transmit time 2032:80 GMT. Program malfunctioned during command transmission; computer reprogrammed. Investigation of problem continues |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 11 | 233 | 0422:56 | 1345:00 | | 0445.00<br>1310.01 | 0422:56<br>0445:00<br><br>1310:01<br>1345:00 | −124.9 | 22 | Exciter VCO printouts from TDH bad; adjusted gain on counter. Momentary power fluctuations at 1030 GMT; trouble corrected at commercial power substation. Dec angle readout biased by 10 deg; cause unknown |
| 5 | 42 | 233 | 1255 | 1904 | | 1245<br>1310<br><br>1310<br>1855.01<br><br>1855:01<br>1904 | | −120.5 | 7 | None |
| | 51 | 233/234 | 1832:19 | 0518 | | 1832:19<br>1855<br><br>1855<br>0455:01<br><br>0455:01<br>0518 | | −123.8 | 8 | Day number not changed at 0000; cause unknown. Standard restart corrected anomaly. Digit list in doppler printout; system reset |
| | 11 | 234 | 0419:40 | 1324:00 | | 0455:00 | 0419:40<br><br>1301:00 | −126.5 | 11 | None |
| 6 | 42 | 234 | 1245 | 2040 | | 1300 | 1245<br><br>1955:01 | −122.5 | 5 | None |
| | 51 | 234/235 | 1940:12 | 0505 | | 1955:00<br>0455:01 | 1940:12<br>1955:00<br><br>0455:01<br>0505:00 | −125.0 | 7 | Degree digit jumping during post-calibrations; cause unknown. Computer operated in command encoder setting due to return of both monitor receivers to JPL per JPL TWX 16/1653 |
| | 11 | 235 | 0416:20 | 1324 | | 0455:00<br>1308:13 | 0416:20<br>0455.00<br><br>1308:13<br>1324:00 | −127.1 | 7 | 0425:00 TDH TTY printing garbled; changed printers 0500:00 TDH dec angle readout error |
| 7 | 51 | 235/236 | 2000:58 | 0518 | | 2000:58<br>2015<br><br>2015<br>0455:01<br><br>0455:01<br>0517 | | −126.8 | 9 | 1442 GMT loss of power in generator due to failure of house voltage regulator on U bus. 1830 GMT punch 2 in TDH inoperative, cause unknown; suspect reader and preamble generator |

# Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 42 | 235 | 1245 | 2027 | | 1245<br>1300<br>1300<br>2015:01<br>2015:01<br>2027 | | −124.6 | 5 | None |
| | 11 | 236 | 0412:38 | 1316.00 | | 0455:00 | 0412:38<br>1300·00 | −128.0 | 8 | Datex dec readout oscillating at time of acquisition; adjusted dec feedback loop. TDH antenna HA angle printout error |
| 8 | 42 | 236 | 1228:37 | 2030 | | 1301<br>1945:01 | 1228:37<br>1300<br>1945:01<br>2030 | −124.8 | 4 | None |
| | 51 | 236/237 | 1929:57 | 0504:44 | 0451:33<br>0504:44 | 1945:00<br>0451:10 | 1929:57<br>1945:00 | −127.3 | 10 | "A" recorder overheating due to faulty fan; fan replaced after track |
| | 11 | 237 | 0415 | 1225:18 | 0451<br>0500 | 0415<br>0451<br>0500<br>1425:18 | | −129.0 | 14 | DSS 12 reported parity errors starting at 0505:00 GMT clearing up 0532:00, cause unknown. Punch No. 1 garbled due to faulty transmitter-distributor. Switched to punch 2 at 0506.00 GMT. TXR unable to achieve sufficient power out to maintain S/C signal at −122 dBmW; track authorized signal of −126 dBmW |
| 9 | 42 | 237 | 1237 | 1955 | 1425:47<br>1436.50 | 1436:50<br>1945:01 | 1237<br>1425:30<br>1945.01<br>1955 | −125.6 | 6 | None |
| | 51 | 237/238 | 1929:30 | 0453:00 | | 1945:00<br>0445:01 | 1929:30<br>1945:00<br>0445:01<br>0453 | −128.6 | 10 | Periodic dropouts of channel 7 ground instrumentation noted on B2 mag tape recording after tape change; tape replaced at 2234 GMT; new recording designated B2 (2), old tape B2 (1). Suspect defective tape. Unable to obtain required S/C AGC level −122 dBmW by TXR power adjustment. Power fixed at 300 W for S/C |
| | 11 | 238 | 0418:37 | 1316 | | 0418:37<br>0445:00<br>0445:00<br>1300.00<br>1300:00<br>1316:00 | | −130.8 | 6 | 0432:02 GMT TDH punch 1 failed due to faulty tape guide; switched to No. 2 punch<br>0502:30 GMT punch 2 failed due to faulty T-D; switched to Punch 1 after repair |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 42 | 238 | 1245 | 2017 | | 1239:43<br>1259<br><br>1304:40<br>1945:01<br><br>1945.01<br>2017 | | −127.3 | 5 | None |
| | 51 | 238/239 | 1930:46 | 0512 | 2032:15<br>2035:00<br><br>0450:00<br>0455.00 | 1945:00<br>2032:14<br><br>2035:00<br>0450.00 | 1930:46<br>1945.00<br><br>0455:00<br>0512:00 | −129.3 | 9 | TXR turned off 5 min early due to operator error. Answers from DSS 51 slow via TTY due to voice circuits down |
| | 11 | 239 | 0402:40 | 1310 | 0450:26<br>0459:38<br><br>1305:00<br>1310:00 | 0402:40<br>0450·26<br><br>0459:38<br>1305:00 | | −132.3 | 7 | 1058:00 GMT Individual channel amplifiers not on; operator error |
| 11 | 42 | 239 | 1232:54 | 2027:03 | | 1305.00 | 1232:54 | −127.2 | 10 | 1340 GMT, Sorenson regulated power supply to maser failed; switched to paramp from 1343 to 1830 then returned to maser. 1940 GMT, −300-V power supply in GOE failed |
| | 11 | 240 | 0416 | 1316 | 0416<br>0446·23 | 0446:23<br>1300.01<br><br>1300.02<br>1316:00 | | −132.5 | 13 | None |
| 12 | 42 | 240 | 1229 | 2100 | | 1300:30<br>2100 | 1237<br>1300 | −127.6 | 15 | 1055 GMT GOE computer buffer causing spurious interrupt to comp.<br><br>1345 GMT B computer failed due to memory parity errors. |
| | 11 | 241 | 0505:06 | 1255 | 0505:56<br>0513:36 | 0513:36<br>1245:01 | 1245:01<br>1255:00 | −133.4 | 24 | Excessive bit error rate DSS 12; bit error tester malfunction |
| 13 | 42 | 241 | 1230 | 2108 | | 1230<br>1245:12<br><br>1245:12<br>2108 | | −128.8 | 31 | None |
| | 11 | 242 | 0354:37 | 1505 | 0354:37<br>0401:44<br><br>1456:01<br>1505:00 | 0401:44<br>1455:00 | | −132.3 | 46 | CEC recorder no galvo lamp excitation<br><br>1015 GMT, voice line to SFOF out |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | | | | | | | | | | No track |
| 15 | 42 | 243 | 1238 | 2100 | 1729:04<br>1844.00<br>2000:46<br>2004:45 | 1239.46<br>1314:00<br>1314:00<br>1729:04<br>1844:00<br>2000:46<br>2004:45<br>2035:00<br>2035<br>2102 | | −130<br>−131.5 | 21<br>· | CEC recorder lamp power supply failed at 1903 GMT |
| | 51 | 243/244 | 2011:00 | 0352:54<br>0400:10 | | 2011.00<br>2045:00<br>2045:00<br>0352:54 | | −132.4 | 7 | Lost HA drive hydraulic pressure at 0346 GMT due to HA pump motor pressure line fracture at output flange. Station was advised that efforts to reconfigure and continue track on SAA would not be necessary since DSS 11 would acquire before completion of reconfiguration. Track terminated at 0352:54 GMT when receiver dropped lock. TFR number to be forwarded |
| | 11 | 244 | 0354 | 1032 | 0354·40<br>0408:34 | 0408:48<br>1032:00 | | −132.7 | 12 | None |
| 16 | 42 | 244 | 1011 | 2050 | 1605<br>1633:08 | 1011:22<br>1027<br>1027<br>1605<br>1633:08<br>2048 | | −130.3 | 27 | At 1218:00 GMT CEC record lamp failed<br>Following command 027 at 2043 GMT, lost W/F sync due to bit rate change, caused a computer alarm at the GOE. Normal procedure is to stop any further commands without exception until alarm is cleared. In this case, DSS 42 operations director advised the GOE operator to ignore the alarm. This appears to be a procedure deficiency |
| 17 | 42 | 245 | 1009:27 | 2045 | 1009 | 1032 | | −130.7 | 36 | 2040:43 GMT. Antenna drive failure due to overload trip on HA regulated power supply. Receiver LOS for 2 s |
| | 11 | 246 | 0336 | 1241 | 0336<br>0349:10 | 0349:10<br>1230:01 | 1230:01<br>1241:00 | −131.5 | 31 | Sanborn recorder gearbox failed. TDH punch 1 tape broke. No tracking data sent from 0718:00 to 0756:00 |
| 18 | 42 | 246 | 1209:53 | 2029:03 | | 1230<br>2029:03 | 1209:53<br>1230 | −131.4 | 28 | None |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 11 | 247 | 0331:05 | 1240 | 0331:05<br>0340.04 | 0340:04<br>1230:01 | 1230·01<br>1240.00 | −136.4 | 29 | None |
| 19 | 42 | 247 | 1209 | 2018:20 | | 1209<br>1230:30<br>1230:30<br>1219 | | −132.1 | 25 | None |
| | 11 | 248 | 0327:02 | 1227 | 0327 02<br>0345:20 | 0345:20<br>1220.01 | 1220:01<br>1227 | −135 2 | 32 | None |
| 20 | 42 | 248 | 1205 | 2007:21 | 1205<br>1220 | 1220<br>2007:21 | | −132.4 | 24 | None |
| | 11 | 249 | 0322:33 | 1217 | 0322·33<br>0330:10 | 0330.10<br>1200:01 | | −133.7 | 32 | FR-1400 recorder B inoperative due to noise on all recording channels |
| 21 | 42 | 249 | 1146 | 2005:22 | | 1100:18<br>2005:22 | 1136·13<br>1200:18 | −133.4 | 27 | Faulty FTS 1-mHz cable caused excessive phase jitter on exciter. Cable replaced. Doppler condition code indicated good from 1630 to 1705, when should read bad |
| | 11 | 250 | 0320:30 | 1306:00 | 0320:30<br>0338:48<br>1258:46<br>1306:00 | 0339:07<br>1234:54 | | −136.6 | 30 | Transfer to DSS 42 delayed due to use of wrong predicts at Station 42 antenna<br>DSS 11 transmitter off at 1245·01<br>DSS 42 transmitter on at 1245:00, 2-way<br>DSS 11 should have been 3-way from 1245:01 to end of track<br>Servo inoperative in autotrack mode. Used spacecraft to rephase angle channels. DSS 12 TCP inserted wrong program in computer. Command sent at 0500 from DSS 12 GOE stopped after eighth bit, possibly due to transient in microwave link. TDH HA printout erroneous |
| 22 | 42 | 250 | 1156:30 | 2025 | | 1245<br>2010 | 1156<br>1245<br>2010<br>2025 | −133.2 | 19 | Transfer from DSS 11 was delayed due to weak signal level caused by antenna operator reading incorrect predicts and autotracking on side lobe<br>Intermittent excessive exciter jitter. Under investigation |
| | 51 | 250 | 1959:29 | 0505 | | 2010:08<br>0448 34 | 1959:29<br>2010.08 | −134.2 | 25 | CMC counter faulty. Synthesizer count on TDH data reading all zeros |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | 42 | 251 | 1152 | 2025 | 1152<br>1200 | 1203:40<br>2005:01<br>2005:01<br>2025 | | −134.4 | 34 | None |
| | 51 | 252 | 1950 | 0435 | | 2005<br>0435 | 1950<br>2005 | −136.4 | 19 | FR-1400-Track 2 data (bit sync) on A3 recording noted to be intermittent at 0137 after B tape change. Failure was at first attributed to poor patch but malfunction later reappeared. When A3 was stopped at 0202 for FSM record module change, the fault cleared. By arrangement with SFOF, suspect A3 recording was retained at DSS 51 and backup forwarded to JPL |
| 24 | 42 | 252 | 1230 | 2024 | 1230<br>1243:11 | 1243:20<br>2005 | 2005<br>2024 | −134.3 | 16 | TDH VCO counter triggering incorrectly. Replaced 20-MHz converter but still had random bad counts |
| | 51 | 252/253 | 1950:00 | 0344.00 | | 2005:01<br>0340:01 | 1950:00<br>2005:01<br>0340:01<br>0344:00 | −136.06 | 6 | IRIG Channel 5 VCO offset low; VCO replaced. GOE error rate tester out during postcalibrations. Under investigation |
| | 12 | 253 | 0309:30 | 1035 | | 0340.00<br>1025:01 | 0309:30<br>0340:00<br>1025:01<br>1035:00 | −136.4 | 15 | F-68 data request due at 0800:46, but was delayed 60 s due to operator error, making it necessary to resend cmds 050, 034, and 004 30 min later |
| 25 | 42 | 253 | 1005 | 1957:55 | 1230<br>1243:20 | 1243:20<br>1957:55 | | −133.5 | 16 | None |
| | 12 | 254 | 0255 | 1043 | 0255<br>0309:45 | 0309:45<br>1035:01 | 1035:50<br>1043 | −137.3 | 18 | Txr power was increased to 1100 W to maintain S/C AGC at −125 dBmW. Acquired 2-way at 1 kW |
| 26 | 42 | 254 | 1013.00 | 1947:11 | | 1036<br>1946:45 | 1005:52<br>1035:00 | −135 | 16 | None |
| | 12 | 255 | 0255 | 1052 | 0255<br>0309 | 0309:15 | | −138.1 | 17 | None |
| 27 | 42 | 255 | 1022 | 1955 | | 1045 | 1022 | −135.7 | 15 | At 1915:10 command 100 to address 4 was 10 s late due to operator error |
| | 12 | 256 | 0250 | 1048 | 0250<br>0306 | 0306:10<br>1048 | | −138.2 | 27 | Blower fan in Alpha tape recorder power supply failed at 0253. Blower replaced. Back in operation at 0309:00. TDH garbled from 0955 to 1017. Machine on line apparently bad as high-speed punch data OK |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 28 | 12 | 257 | 0245 | 1350 | 0245<br>0255:14 | 0255:14 | | −138.4 | 24 | Station on APS instead of auto-track. Station reports they have been authorized to go APS full time |
| 29 | 12 | 258 | 0245 | 1120 | 0245<br>0305:09 | 0305:09<br>1119:29 | | −139.4 | 20 | At 0245:30 the HA readouts from TDH were erratic: Problem was traced to DIS and a cable used to carry HA data to DIS for use with APS. A temporary fix was incorporated. TDH data from 0258 to 0349 was bad in the HA column |
| 30 | 12 | 259 | 0240 | 1350 | 0240<br>0251 | 0251 | | −138.8 | 33 | TDH reperforation tape data bad |
| 31 | 12 | 260 | 0236:00 | 1341 | 0236:00<br>0250.51 | 0251:40<br>1341 | | −140.2 | 28 | Station used paramp during this pass due to maintenance on maser. High bit error rate was experienced until paramp pump power was adjusted. This caused reading to drop from 0.273 to 0.089 |
| 32 | 12 | 261 | 0215 | 1339 | 0215<br>0235:44<br>1330<br>1339 | 0235:56<br>1330 | | −140 | 34 | None |
| 33 | 61 | 261/262 | 2025:29 | 0225:00 | 2025:29<br>2040:00 | 2040:00<br>0210.02 | 0210.02<br>0225 00 | −139.1 | None | Record-only pass. |
| | 12 | 262 | 0200 | 1339 | 0210 | 0210:33 | 0200 | −139.9 | 31 | Maser heated up during pass, and station switched to paramp, but returned to maser after breakdown of Joule-Thompson circuit pump. Station hit limits 14 min before end of track and 3 min before scheduled transfer |
| 34 | 41 | 262 | 1320:00 | 2050.00 | 1516.02<br>1525:14 | 1331:00<br>1515:23<br>1525:14<br>2045:01 | 1320:00<br>1331 00<br>2045 01<br>2051:20 | −138.9 | None | Record-only pass |
| | 61 | 262/263 | 2024:03 | 0216.00 | | 2045:00<br>0205:04 | 2024:03<br>2045:00<br>0205:04<br>0216:00 | −139.8 | None | Record-only pass. Station had to retune paramp for channel 6 due to low gain |
| | 12 | 263 | 0153 | 1336:53 | | 0205:34<br>1320:02 | 0153.00<br>0205<br>1324:40<br>1336-53 | −140.1 | 15 | None |

### Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 35 | 41 | 263 | 1317:00 | 2046:30 | | 1320:32<br>2035:01 | 1317:00<br>1320:00<br>2035:02<br>2046:30 | −138.6 | None | Record-only pass |
| | 61 | 263/264 | 2008:45 | 0544:07 | | 2035:38<br>0544:07 | 2008.45 | −139.8 | None | Record-only pass |
| | 12 | 264 | 0614 | 1329 | 0614<br>0626:06 | 0626.21<br>1329.00 | | −139.6 | 18 | There were no TDH doppler readouts until 0637 as doppler counter power supply was turned off |
| 36 | 41 | 264 | 1330:00 | 2043:15 | 1614:53<br>1623:15 | 1330:40<br>1614:53<br>1623:15<br>2043·15 | 1329:10<br>1330:40 | −138.8 | None | Record-only pass. Transmitter tripped off at 1614:17. Cause was undetermined |
| | 61 | 264/265 | 2011:21 | 0500 | 2257:55<br>2320:00 | 2320:35<br>0450:01 | 2011:21<br>2035:51<br>0450:01<br>0500 00 | −140.7 | None | Station experienced card failure in TDH equipment. Switch S-4 on test signal control caused noise when placed in RCVR position |
| | 12 | 265 | 0430 | 1100 | | 0450:35<br>1050:00 | 0430<br>0450:36<br>1051<br>1100 | −140 5 | 10 | None |
| 37 | 41 | 265 | 1030 | 2038 | | 1050·34 | 1030<br>1050 | −139.1 | None | Record-only pass |
| | 61 | 265/266 | 2003:00 | 0520:00 | | 2030<br>0510 | 2003:00<br>2030:00<br>0517:31<br>0520:00 | −141.1 | None | Record-only pass |
| | 12 | 266 | 0450:00 | 1300·30 | | 0510:36<br>1245:00 | 0450:00<br>0500:35<br>1245:01<br>1300:30 | −140.0 | 9 | None |
| 38 | 41 | 266 | 1230:00 | 2035:52 | | 1245:36<br>2020.01 | 1230·00<br>1245:36<br>2020:01<br>2035:52 | −138.8 | None | Record-only pass |
| | 51 | 266/267 | 2000.02 | 0347:30 | | 2020:40<br>0335:30 | 2000:02<br>2020.40<br>0335:30<br>0347:30 | −140.2 | 6 | None |
| | 12 | 267 | 0315 | 1030 | | 0335:37<br>1020:40 | 0315:00<br>0335:37<br>1020.40<br>1030:00 | −140.4 | 11 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 42 | 267 | 1001 | 1850 | | 1021<br>1830 | 1001<br>1021<br>1830<br>1850 | −141.0 | 4 | None |
| | 51 | 267/268 | 1808:36 | 0300 | | 1831 | 1808:36<br>1830<br>0250.30 | −140.45 | 4 | None |
| | 12 | 268 | 0230 | 1100 | | 0250:38<br>1050:02 | 0230<br>0250:38<br>1050:02<br>1100 | −141.0 | 17 | None |
| 40 | 42 | 268 | 1023 | 1855 | | 1058<br>1850 | 1023<br>1058<br>1850<br>1855 | −141.1 | 4 | None |
| | 51 | 268/269 | 1824 | 0310 | | 1850<br>0250:01 | 1824<br>1850<br>0250:01<br>0310.00 | −140.0 | 4 | None |
| | 12 | 269 | 0230:00 | 1030.00 | | 0250:39<br>1020:01 | 0230:00<br>0250:00<br>1020:01<br>1030.00 | −140.8 | 11 | None |
| 41 | 42 | 269 | 0955:15 | 1856.00 | | 1024:00<br>1823:10 | 0955:15<br>1020:00<br>1823:10<br>1856.00 | −141.4 | 4 | None |
| | 51 | 269/270 | 1800:02 | 0236:00 | | 1820:00<br>0230:01 | 1800.02<br>1820:00<br>0230·01<br>0236:00 | −141.2 | 4 | An increase in bit error rate occurred at 1910, possibly due to diplexer arcing. After 20 min, rate returned to normal. There were no further occurrences |
| | 12 | 270 | 0200:00 | 1030:00 | | 0230.40<br>1020:01 | 0200.00<br>0230:00<br>1020:01<br>1030:00 | −141.4 | 10 | None |
| 42 | 42 | 270 | 0957:00 | 1846:00 | | 1029:14<br>1820:01 | 0957:00<br>1010:40<br>1821:00<br>1846:00 | −141.8 | 4 | None |
| | 51 | 270/271 | 1758:52 | 0305:00 | | 1820:00<br>0300.01 | 1758:52<br>1820:00<br>0300:01<br>0305:00 | −141.0 | 20 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 12 | 271 | 0230.00 | 1040.00 | | 0300:50<br>1020:01 | 0230:00<br>0300.00<br>1020:01<br>1040:00 | −142.3 | 29 | At 0854:15, computer stopped and had to be restarted. There was no reoccurrence |
| 43 | 42 | 271 | 1003 | 1840 | | 1020<br>1820 | 1004<br>1020<br>1820<br>1840 | −142.05 | 6 | None |
| | 51 | 271/272 | 1758:52 | 0322 | | 1820:41<br>0320:01 | 1758:52<br>1820.00<br>0320:01<br>0322:00 | −141.6 | 7 | No deviation from carrier frequency was noted on input signal to FR-1400 wide-band frequency-modulated record electronics. Module was replaced |
| | 12 | 272 | 0300 | 1030 | | 0320:43<br>1020:01 | 0300.00<br>0320.00<br>1020:42<br>1030:00 | −142.4 | 10 | None |
| 44 | 42 | 272 | 1000:00 | 1740:00 | 1149:55<br>1235:29 | 1020<br>1149<br>1235:41<br>1720:01 | 1000<br>1020<br>1720:01<br>1740:00 | −141.6 | 4 | None |
| | 51 | 272/273 | 1700:01 | 0135:00 | | 1720:00<br>0135:00 | 1700 01<br>1720:00 | −142.0 | 6 | None |
| | 12 | 273 | 0109:40 | 1253·42 | 0136:16<br>0159:52 | 0159·56<br>1253:42 | 0109.40<br>0135.46 | −142 3 | 14 | None |
| 45 | 42 | 273 | 1235 | 1832 | | 1311:44<br>1805:00 | 1235:00<br>1311:44<br>1805:00<br>1832:00 | −142.8 | 2 | Antenna began to run away while in auto track mode due to bad integrator module, which was replaced. Transmitter caused high noise level in system until end of two-way tracking |
| | 51 | 273/274 | 1758:40 | 0308.00 | 0306:09<br>0308:00 | 1820:00<br>0305:00 | 1758:40<br>1820:00 | −142.3 | 6 | None |
| | 14 | 274 | 0250 | 0845 | 0250<br>0845 | | | −133.0 | None | At 0259:30, operator inadvertently entered wrong offset into antenna pointing system, causing receiver to lose lock |
| 46 | 12 | 275 | 0122:19 | 1248 | 0122:29<br>0125·45<br>0129.08<br>0133:01 | 0125:45<br>0128:54<br>0133:01 | | −142 7 | 18 | After satisfactory transfer at 0125, station dropped uplink while tuning to syn frq, cause unknown. Double N frame request not accomplished because antenna hit prelimits at 1244:37 |
| | 51 | 274/275 | 1659 | 0128:35 | 1659<br>1725<br>0125:01<br>0128:35 | 1725:45<br>0125:01 | | −142.7 | 6 | Battery temperature error indicated on class I printout corrected by a computer reload |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 42 | 274 | 0806 | 1731 | 0806<br>0823:06 | 0823·06<br>1725:01 | | −142.9 | 15 | Extensive tests carried out, prior to pass, to isolate cause of TXR noise spikes-klystron suspected. (Problem did not occur during this pass.) |
| 47 | 42 | 275 | 1230 | 1830 | 1230<br>1235<br>1815:01<br>1830 | 1235<br>1815.01 | | −143.1 | 5 | DIS program was reloaded at 1426 due to an anomaly in the S/C battery current printout. Subsequent printouts all right |
| | 51 | 275/276 | 1756:05 | | 1756:05<br>1815:55 | 1815:55<br>0310:44 | | −142.4 | 7 | None |
| 48 | 12 | 277 | 0100:15 | 0940:00 | 0100:15<br>0115:00 | 0128:30<br>0920:01 | 0920:50<br>0940:00 | −143.2 | 13 | None |
| | 42 | 276 | 0757:10 | 1703·20 | 0757:10<br>0812:39 | 0812:39<br>1702·30 | | −143.6 | 21 | None |
| 49 | 42 | 277 | 0900:09 | 1817:52 | | 0920.50<br>1817:00 | 0900:09<br>0920.00 | −143.4 | 9 | None |
| | 12 | 278 | 0054:30 | 1234:23 | 0054:30<br>0100 | 0108:56<br>1231:20 | | −143 3 | 26 | Receiver out of lock due to antenna driving off signal source while computer driven. Post-cals deleted due to scheduled *Lunar Orbiter* mission |
| 50 | 12 | 279 | 0230.00 | 1107 | 0230<br>0243 | 0243:40<br>1105 | | −144.2 | 20 | None |
| 51 | 12 | 280 | 0044:00 | 0900.00 | 0116<br>0132 | 0134:25<br>0900 | | −146.5 | 13 | Locked up on channel 7 at TXR VCO·9077.0 Hz. (Signal strength, −145.3 dBmW.) |
| | 51 | 279/280 | 1829:55 | 0120 | 1829:55<br>1841:53<br>0116.24<br>0120 00 | 1842:15<br>0115:54 | | −143.3 | 10 | None |
| 52 | 42 | 280 | 1200:00 | 1830:00 | 1200:00<br>1256:26 | 1257:35<br>1820.01 | 1820:01<br>1821:56<br>1822:12<br>1830:00 | −144.1 | 13 | TXR radiating from SAA instead of SCM due to operator error. This resulted in inability to acquire uplink until corrected at 1256 |
| | 51 | 280 | 1758 | 0243 | | 1822:11<br>0243 | 1758<br>1820 | −144.3 | 9 | No post-cals due to rescheduling for *Surveyor I* revival. During pre-cals antenna Dec high-speed tachometer not functioning. Tach changed. Demodulator out of lock at 020600 due to operator not changing to 8 bits/s after CMD 027 was sent |
| 53 | 12 | 282 | 0040 | 1220 | 0040<br>0053:44 | 0053:44<br>1218:35 | | −143.8 | 21 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 12 | 283 | 0033 | 0848 | 0033<br>0039 | 0045:10<br>0846.50 | | −144 7 | 18 | Track mentions the F-68 request at 0825:07 that the frames are not in sequence |
| 56 | 12 | 285 | 0023:30 | 1157 | 0023:30<br>6034:00 | 0034<br>1157 | | −145.0 | 21 | TTY page print failure necessitated switch to another machine |
| 58 | 12 | 286/287 | 0030 | 1156 | 0030<br>0048:40 | 0048<br>1156 | | −145.4 | 15 | 0626 CMD 3/062 entered in error for 3/052 and would not verify. 1042 CMD 3/053 entered before CMD tape changed so would not verify |
| 59 | 51 | 287 | 1504 | 0218 | 1504<br>1515:30 | 1515:30<br>0218 | | −145.9 | 15 | TDH synthesizer reading in error from beginning of track to 1826. Cause was low-power supply gain setting on times 5 multiplier. FSM record module faulty. "A" recorder replaced. FSM reproduce module faulty. "B" recorder replaced |
| 60 | 12 | 289 | 0013:03 | 1146:00 | 0013.03<br>0039:10 | 0039:34<br>1125:00 | 1125:00<br>1146:00 | −145.6 | 14 | None |
| 61 | 41 | 289 | 1115:00 | 1830:05 | | 1141:20<br>1750.01 | 1115:00<br>1141:20<br>1750:01<br>1830:05 | −145 2 | None<br>(No GVE) | Record-only. During postcalibrations telemetry phase detector was found set 80 deg from correct position due to operator error |
| | 51 | 289 | 1729:20 | 0200:00 | | 1751:10<br>0201:20 | 1729:20<br>1750 | −146.1 | 9 | Solar flare pass |
| 63 | 12 | 292 | 0002:18 | 1143:18 | 0002:18<br>0015:20 | 0016:20<br>1143:18 | | −148.9 | 21 | None |
| 65 | 12 | 293/294 | 0001 | 1135:18 | 0001.00<br>0006:43 | 0007:04<br>1135:18 | | −147.1 | 21 | Scheduled JPL power outage caused all lines to be down from 0159 to 0400. Microwave failure caused loss of all lines from station to JPL |
| 66 | 12 | 295 | 0300 | 1125 | 0300:00<br>0310:33 | 0310.46<br>1125 | | −147.1 | 19 | Receiver noted 2 momentary dropouts on AGC meter at approximately 0704 for no apparent reason |
| 68 | 12 | 296/297 | 2348:12 | 1124:52 | 2348:12<br>0007:28 | 0007·39<br>1124:52 | | −147.5 | 25 | Station could not lock computer after XTM (MI) sequences. Signal from S/C abnormally high and varying in phase after CMD sequence. Computer locked after CMD retransmitted to change bit rate |
| 70 | 12 | 298/299 | 2353:10 | 1121:16 | 2353:10<br>0043:45 | 0043:45<br>1121:16 | | −148.1 | 25 | None |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 72 | 51 | 300 | 1457 | 2054 | 1457<br>1508:36 | 1509:09<br>2052 | | −147.9 | 15 | B recorder tape stretching transducer air passages and orifices. Trace identifier intermittent operation at 29690. Gear replaced. LO crystals instead of *Pioneer* crystals changed. WBFM modulator channel 3 on recorder "A" faulty; replaced |
| 74 | 12 | 302/303 | 2331 | | 2331<br>2343:22<br>0108:48<br>0124:18 | 2343:22<br>0108:48<br>0124:18<br>1100:00 | | −149.1 | 18 | Blown fuse in temperature control circuit; heat exchanger off |
| 76 | 12 | 304/305 | 2326:17 | 1100 | 2326:17<br>2347:15 | 2347:15<br>1100 | | −152.4 | 23 | Unable to run receiver post-cals due to the nonavailability of an operational signal source. This may have effected pre-cals as well and suspect that all reported signal levels are bias by minus 4 dB. Unable to confirm, however, at this time |
| 78 | 12 | 306/307 | 2315:15 | 1055 | 2315:15 | 2356<br>1055 | | −151.9 | 16 | TDH tracking data garbled-note on post track |
| 80 | 11 | 308/309 | 2346:29 | 0755:00 | 0005:01<br>0005:30 | 0005:30<br>0755:00 | 2346:29<br>0005:01 | −150.7 | 19 | TDH sample time read out errors |
| | 51 | 308 | 1415:49 | 0040 | 1415:49<br>1431:30 | 1431:30<br>0005:01 | | −149.6 | 18 | Leak in HA angle drive-pipe replaced. Lost transmitter power so reduced to 9 kW |
| 82 | 51 | 310 | 1404 | 1651:30 | 1404 00<br>1416:00 | 1416:00<br>1651:30 | | −150.7 | 8 | None |
| 85 | 11 | 313/314 | 2335:35 | 0750.00 | | 2359:18<br>0750:00 | 2335:35<br>2355 | −146.3 | 17 | TDH erratic sampling times from 0300 to 0510. CEC timing light failure |
| | 51 | 313 | 1355 | 0020 | 1355<br>1417:29 | 1417:29 | | −151.0 | 12 | Recorder trouble due to improperly degaussed tape which contained *Mariner IV* data |
| 86 | 11 | 314/315 | 2329:53 | | 0329:49<br>0332:02 | 2352:30<br>0255.45<br>0338:42<br>0743:00 | 2329:53<br>2350.00 | −151.6 | 18 | Low-speed tachometer MSFN/DSIF switch failure during pre-cals. TDH rate failure |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 51 | 314 | 1347:56 | 315/0000 | 1347:56<br>1422:37 | 1422:37<br>2350:01 | 2352.00<br>0000:00 | −151.4 | 9 | During count down, cooling fan on a recorder developed a noisy bearing causing insufficient cooling and inability to set up tracks 5 and 6. Bearing was lubricated and forced cooling of overheated bay begun. Stability restored and countdown proceeded. TXR tripped due to airleak in non-return valve to surge tank in heat exchanger. Nitrogen bottle connected to stop leak |
| 87 | 11 | 315/316 | 2326:25 | 2359:22 | 0002:19<br>0016·22 | 0017:30<br>0615:37 | 2326:25<br>2359:22 | −151.0 | | Loss of waveguide pressure caused TXR interlock-protect to turn TXR off. Switched S/C transmitter from channel 6 to channel 7 at 0002:19 |
| | | | 0002:19 | 0751 05 | 0632:28<br>0647:06 | 0647:15<br>0748:04 | | | 11 | |
| | 51 | 315 | 1344:11 | 316/0000 | 1344:11<br>1400:40 | 1400:40<br>2359:22 | | −151.1 | 11 | TXR dropped down to 3-4 kW, but readjustment restored power to 10 kW. No explanation |
| 90 | 51 | 318/319 | 1339.02 | 0043 | 1339.02<br>1500:03 | 1500.03<br>0042 | | −151.6 | 15 | Due to critical klystron tuning, power slipped off; brought back to 10 kW |
| 91 | 51 | 319 | 1337:35 | 0032 | 1337<br>1348:53 | 1348:53<br>0027 | | −152.0 | 15 | Lost TXR for 1 min, suspect klystron |
| 92 | 51 | 320 | 1339:34 | 0007 | 1339:34<br>1356.35 | 1356:35<br>0003 | | −152.2 | 15 | Station concerned about TXR VCO being 4-5 Hz below predicts |
| 93 | 51 | 321/322 | 1332:26 | | 1332:26<br>1349:41 | 1350:16<br>0033:00 | | −153.1 | 14 | Maser trouble. Repressurized for balance of mission |
| | 11 | 322 | 0056:02 | 0830 | 0056:02<br>0257:15 | 0257:15 | | −155 | 15 | CEC recorder inoperative. TDH Dec angle readout dropping one digit on two occasions |
| 94 | 51 | 322 | 1331:31 | 2355 | 1331:31<br>1356:43 | 1356:33<br>2342 | | −153.1 | 8 | None |
| | 11 | 322 | 2307:05 | 0820:00 | 2307:05<br>2343:47 | 2343:47<br>0820.00 | | −152.9 | 9 | None |
| 96 | 51 | 324 | 1327:15 | 0020:00 | 1327:15<br>1355:54 | 1355:54<br>0020:00 | | −152.9 | 13 | None |
| 97 | 51 | 325 | 1327:00 | 2355:00 | 1327:00<br>1345:00 | 1345:32<br>2355:00 | | −153.0 | 15 | None |
| 98 | 11 | 326 | 2257:40 | 0825:00 | 2257 40<br>2330 | 2330<br>0825 00 | | −152.8 | 13 | None |
| | 51 | 326 | 1342:52 | 2347·00 | 1342:52<br>1343:15 | 1343:15<br>2347:00 | | −153.3 | 14 | Recorder lamp failed |
| 99 | 51 | 327 | 1320:20 | 2344 | 1320:20<br>1336:45 | 1336:45<br>2344 | | −154.0 | 12 | TXR kicked off, no explanation |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 11 | 327/328 | 2254:58 | 0825 | 2345:57<br>2356:03 | 2357:06<br>0823:40 | 2254:58<br>2345:57 | −151.2 | 17 | Engineering telemetry began to print out repeated class I engineering data (14 to 11 min). Timing and bit error were bad and helix current changed from 6.37 to 6.62: Cause was *Lunar Orbiter* lost source data. During occultation, a tape readback was requested. Misplaced switches resulted in astrodata time loss and interference of *Pioneer* telemetry data. At −3 dB (1 kW), receiver was out of lock 50% of time |
| 101 | 51 | 329 | 1325:49 | 0005 | 1325:49<br>1339:00 | 1339:00<br>0005 | | −153.5 | 15 | Engineering data lost due to TCP operator having BP2 set for teleprinter. Change FPR |
| 103 | 14 | 332 | 0319Z | 0956 | 0319<br>0413:44 | 0414:16<br>0956 | | −144.0 | 17 | None |
| 105 | 51 | 333 | 1318:14 | 2357 | 1318:14<br>1338:02 | 1338:02<br>2353 | | −154.2 | 13 | During tape change on FR-1400, supply reel would not tighten due to hub trouble. Lost 21 min of data |
| 106 | 51 | 334 | 1315:17 | 2350 | 1315:17<br>1324 | 1324:36<br>2350:00 | | −155.2 | 14 | None |
| 107 | 51 | 335 | 1316:33 | 2311:00 | 1316.33<br>1339:37 | 1342:34<br>2300:01 | 2300.01<br>2311:00 | −155.2 | 9 | None |
| | 11 | 335 | 2223 00 | 0824:00 | 2223:00<br>2303:00 | 2303:00<br>0824 | | −154.9 | 7 | None |
| 108 | 51 | 336 | 1305:47 | 2257 | 1305:47<br>1334:50 | 1334:50<br>2300.01 | 2221:10<br>2300 | −154.9 | 9 | None |
| | 11 | 336/337 | 2221:10 | 0800 | 2301:41<br>2315:00 | 2327:00<br>0800:00 | | −2.95 | 16 | Maser gain unstable due to excessive cross head modulation. No AGC post-cals due to maser problem |
| 111 | 51 | 339 | 1307:26 | 2341 | 1307:26<br>1326:58 | 1327:46<br>2341 | | −155.3 | 13 | Communication circuit problems |
| 112 | 51 | 340 | 1306:33 | 2341 | 1306:33<br>1328:20 | 1329:24<br>2341:00 | | −155.3 | 15 | None |
| 113 | 51 | 341 | 1308:23 | 2335 | 1308:23<br>1333:11 | 1334:01<br>2335 | | −155.7 | 15 | None |
| 114 | 11 | 342/343 | 2347:00 | 0831 | 2358:00 | 0024:34<br>0831 | 2347:00<br>2348:00 | −153.9 | 15 | PN-6 tape in computer necessitated computer restart. DEMOD SYNC BITRATE switch at 64 bits/s instead of 16 bits/s. Maser problems at start of pass. Trouble traced to contaminated nitrogen lines. CMD check not entered for CMD 3/101 |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 51 | 342 | 1302-57 | 2345 | 1302:57<br>1320:57 | 1321:56<br>2345 | | −155.5 | 14 | Pass extended due to DSS 11's inability to track. (Masers 1 and 2 down.) |
| 115 | 51 | 343. | 1300:39 | 2236 | 1300.39<br>1326:50 | 1327:32<br>1336 | 2203<br>2238:23 | −155.5 | 9 | None |
| | 11 | 343/344 | 2203 | 0816 | 2238:38<br>2255:58 | 2259·29<br>0816 | | −156.1 | 16 | None |
| 116 | 51 | 344 | 1250:10 | 2050:00 | 1250:10<br>1303:43 | 1304·55<br>2050.00 | | −155.7 | 15 | Solar flare pass |
| 117 | 51 | 345 | 1248:58 | 2241:00 | 1248·58<br>1328:10 | 1328:45<br>2220:01 | | −155.9 | 11 | None |
| | 11 | 345/346 | 2159:23 | 0936.00 | 0856:49<br>0936 00 | 2224:00<br>0855:50 | 2159:23<br>2224:00 | −156.5 | 12 | Solar flare pass |
| | 12 | 346 | 0920:00 | 0936 | 0920:00<br>0930·56 | 0930:56<br>0936.00 | | | 2 | Station 12 up one way. Attempting to put S/C into DCS before set. Command failed to reach S/C before horizon set |
| 118 | 51 | 346 | 1259:27 | 2320:30 | 1259:27<br>1307:24<br>1310:55<br>1443:26 | 1444:41<br>2320.30 | | −157.8 | 13 | Low signal strength was result of maser being peaked at wrong value, (2275 instead of 2295 on spectrum analyzer) causing IF values on IF strip reference channel to be wrong. AGC adversely affected |
| 119 | 51 | 347 | 1256:27 | | 1256:27<br>1311:40 | 1315:30<br>2320 | | −155.6 | 33 | None |
| 120 | 12 | 348 | 2145 | 0909:39 | 2145<br>2220 | 2220.38 | | −156.5 | 26 | Solar flare |
| | 51 | 348 | 1253:00 | 2221 | 1253:00<br>1317:52 | 1317:56 | | −156.1 | 17 | None |
| 121 | 12 | 349 | 2223:00 | | 2315:53 | 2335:26 | 2223<br>2310 | −157.9 | 26 | None |
| | 51 | 349 | 1251:58 | 2310 | 1251:58<br>1311:12 | 1312:32<br>2310 | | −156 6 | 15 | None |
| 122 | 51 | 350 | 1256:32 | 2311:30 | 1256:32<br>1312:15 | 1313:16<br>2311:30 | | −157 | 18 | At 1428 S/C AGC was −137, loop stress −5.00 (for some time duration). At 1528 the class I engineering printout indicated S/C AGC at −134 and loop stress −23. Four subsequent SIERRA printouts indicated the same; at 1547 the engineering printout was normal. No explanation |
| 124 | 51 | 352 | 1253:03 | 2315.00 | 1253:03<br>1305:07 | 1308:03<br>2314:14 | | −156.6 | 18 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 125 | 51 | 353 | 1243:58 | 2319:00 | 1243:58<br>1304·56 | 1307:06<br>2319 | | −157.3 | 20 | S/C signal strength increased abruptly to −147, then slowly decreased to −157.0. No explanation |
| | 12 | 354 | 0007:04 | 0910 | 0007:04<br>0034:10 | 0034:40<br>0910:00 | | −157.0 | 26 | None |
| 126 | 51 | 354 | 1244:42 | 2300:00 | 1244·42<br>1302:05 | 1303:11<br>2245:01 | 2245:01<br>2300:00 | −157.5 | 16 | None |
| | 12 | 354 | 2224:24 | 0909 | | 2248:57<br>0909:00 | 2224.24<br>2248:57 | −157.3 | 17 | None |
| 127 | 51 | 355 | 1243:48 | | 1243:48<br>1301:09 | 1302:11 | | −157.9 | 16 | None |
| | 12 | 355/356 | 2217:08 | 0905 | 2319:50<br>2337:54 | 2337:54<br>0905 | 2217:08<br>2315:16 | −157.5 | 18 | Receiver glitches occurring after RTLT subsequent to each command. No explanation |
| 128 | 51 | 356 | 1241:19 | 2256 | 1241:19<br>1259:27 | 1301.06<br>2256 | | −157.3 | 15 | None |
| 133 | 12 | 361 | 2139:15 | 0006 | 2139:15<br>2204:35 | 2204:35<br>0006 | | −160.7 | 4 | Station tracking on paramp due to maser failure. Prior to track, RCV had several glitches during acquisition due to low signal strength on paramp. Pass terminated with DSN-OCC project approval at 0006, because error rate too high |
| | 51 | 361 | 1233:24 | 2259 | 1233:24<br>1251:08 | 1251:48<br>2259 | | −157.7 | 14 | None |
| 134 | 51 | 362 | 1232:18 | 2155 | 1232:18<br>1251:52 | 1255:12<br>2155 | | −158.57 | 13 | Pass terminated at 2200 because DSS 12 cannot track and all voice and TTY circuits out after 2200 between Pretoria and Johannesburg. At 2150, CMD 053/3 sent in emergency mode. Not permissive on ALOX tape |
| 135 | 12 | 363 | 2145 | 0857:49 | 2346 | 0045:25 | 2145:00<br>2249:29 | −159 | 16 | At 2346, station acquired 1-way on channel 6. Reason for delay was that operator misplaced decimal on $D_1$ doppler |
| | 51 | 363 | 1228:28 | 2245·00 | 1228:28<br>1303:51 | 1304:37<br>2245:00 | | −158.4 | 4 | Several receiver glitches experienced but no explanation available |
| 136 | 51 | 364 | 1228:25 | 2232:00 | 1228:25<br>1308:40 | 1310:19<br>2232:00 | | −159.15 | 11 | None |
| 140 | 51 | 003 | 1227:06 | 2156:00 | 1227:06<br>1251:40 | 1251:40<br>2156·00 | | −160.94 | 9 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 14 | 003/004 | 2056:22 | 0840 | 2056:22<br>2140:29<br>2144:52<br>2000:17<br>2304 08<br>2306<br>2331:02<br>2348:25 | 2000.55<br>2300<br>2301:38<br>2303<br>2348:45<br>0824:45 | 0825<br>0840 | −149.8 | 30 | Command to switch receiver 2 to high-gain antenna was sent 3 times. It was observed, however, to have taken effect upon receipt of the first command |
| 141 | 42 | 004 | 0759:43 | 1400 | | 0824:47<br>1354:49 | 0759:43<br>0824:47 | −157.4 | 0 | Record only pass |
| | 51 | 004 | 1330 45 | 2220 | | 1356:00<br>2219:51 | 1330.45<br>1354:45 | −158.7 | 7 | None |
| | 12 | 004 | 2134:30 | 0845:50 | | 2249<br>0845.50 | 2134:30<br>2219:51<br>2228:30<br>2247:19 | −158.4 | 11 | None |
| 142 | 42 | 005 | 0757:08 | 1411 | 0943:37<br>1014·24 | 0847:08<br>0919:48<br>1016:06<br>1334:51 | 0757:08<br>0845:52 | −158.9 | Record only | When station went 2-way at transfer, TXR tripped off (ARC detector interlock). TXR was on again 15 s later when 2-way was held for about 25 min. TXR then tripped off again |
| | 51 | 005 | 1312 01 | 2129 | | 1345:08<br>2127.55 | 1312:01<br>1343:23 | −158.8 | 15 | None |
| | 12 | 005/006 | 2110 | 0755 | 2130:44<br>2147.50<br>2317:12<br>2350·56<br>0032:15<br>0755:00 | 2151:48<br>2304·54 | 2110<br>2127:53 | −158.1 | 3 | Station power outage. TXR outage due to loss of 400-Hz power source. Further investigation revealed klystron to be source of problems. Personnel decided 6-12 h would be required to determine total problems and perform corrective action. Remainder of station 12 pass will be record only |
| 143 | 51 | 006 | 1225:12 | 2228.00 | 1225<br>1302 | 1302<br>2228 | | −159.2 | 8 | None |
| | 12 | 007 | 0000 | 0828 | 0000<br>0015.38 | 0017:20<br>0826:00 | | −158.4 | 22 | None |
| 145 | 51 | 008 | 1222:16 | 2205 | 1222:16<br>1249:28 | 1249:28 | | −159.4 | 28 | None |
| 146 | 11 | 009 | 2143:20 | 0826 | 2220.07<br>2310:38 | 2206·40<br>2215:50<br>2315:26<br>0826 | 2143:20<br>2156:45<br>2201:46<br>2205:10 | −158.5 | 17 | Station scheduled to acquire at 2104. Could not acquire until 2143:20. Transfer delayed. DSS 11 acquired 3-way, then 2-way, then lost it again; then went 1-way for 50 min. Acquired 2-way at 2315:26. Cause of trouble undetermined |

### Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| | 51 | 009 | 1241:30<br>1318:44 | 2223 | 1241:30<br>1303:58<br>1318:44<br>to<br>1335:23 | 1335:23<br>2147:20<br>2159:40<br>2205:09 | 2206:53<br>2215:55 | −160.6 | 8 | None |
| 147 | 51 | 010 | 1219:03 | 2213 | 1219:03<br>1248:37 | 1249:59<br>2205:55 | | −160.3 | 12 | None |
| 148 | 51 | 011 | 1215:15 | 2220:00 | | 1307:01<br>1319:49<br>1320:22<br>1321:58<br>1322:31<br>2218:34 | 1215·15<br>1228·29<br>1230.15<br>1230.45<br>1232:15<br>1303:38 | −160.1 | 5 | Signal level very low at beginning of pass (−163.4 dBmW) due to maser gain changing since station had done pre-cals. No explanation available |
| | 11 | 011 | 2105:50 | 0844:00 | | 2207:40<br>2218:55<br>2229:20<br>0808 | 2105:50<br>2205:30 | −159.4 | 18 | Station increased power to 16 kW at JPL request. CMD 4/016 sent at 0305 did not get in at 10 kW. S/C AGC at 142 while DSS 11 tracking (at 10 kW) and 139 while DSS 51 tracking. No explanation. High noise level on microwave |
| | 41 | 011 | 0442:08 | 1315 | 0442 08<br>0507:08<br>0516.40<br>0536:27<br>0538:50<br>0614:38 | 0510:39<br>0511:15<br>0614:53<br>0626:37<br>0628 44<br>13 | | −159.3 | None | None |
| 149 | 11 | 012 | 2102:39 | 0831 | 2102·39<br>2128:43<br>2336.28<br>0053:00<br>0102:14<br>0217:50<br>0401:13<br>0506:42<br>0606:50<br>0711·47 | 2131·51<br>2335:18<br>0054:34<br>0100:34<br>0219.23<br>0401:13<br>0506:50<br>0605:18<br>0721:13<br>0831:00 | | −158.3 | 17 | None |
| 151 | 11 | 014 | 2103 | 0827 | 2103:48<br>2136·40 | 2137:40<br>2218<br>2221<br>2318<br>2320<br>0826:42 | | −160.8 | 15 | Station dropped lock at 2218–2221 and again at 2318–2320. Re-adjusted command modulation level to 200 mV. No further problem. CMD modulation level set to 200 mV. during pre-cals, but rose to 300-400 mV. and caused 0/0/L conditions. (It comes over to DSS 11 by microwave from DSS 12.) |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 51 | 014 | 1212 | 2146 | 1212:00 | 1241:47<br>2136:37 | | −160.2 | 22 | None |
| 153 | 51 | 016 | 1210·51 | | 1210:51<br>1230·59 | 1234:55<br>2100:1 | | −160.2 | 19 | None |
| | 14 | 016 | 2033 | 0839 | | 2106<br>0837:58 | 2033:00<br>2106 | −150 3 | 57 | Bit rate changed from 512 to 256 to 16 to 8 and back several times. Lunar occultation rehearsal. S/C placed in noncoherent mode for most of pass |
| 154 | 12 | 017/018 | 2106:07 | 0830 | 2106.07<br>2122:40<br>0100.06<br>0113:45<br>0327:22<br>0651<br>0750<br>0806:02 | 2123<br>0059.38<br>0129:34<br>0326<br>0806:50<br>0829:40 | | −159.8 | 18 | Bit rate 16, 64, 16. Conducted channel 6 coherent and non-coherent threshold checks |
| | 62 | 017 | 1347 | 1655 | 1347:00<br>1406:44 | 1410:35<br>1645:37 | | −163.9 | 0 | None |
| 155 | 12 | 018 | 2050.00 | 0829.00 | 2050.00<br>2114:29 | 2114:55<br>0815:00 | 0815:01<br>0829:00 | −160.7 | 13 | Special procedure practice for occultation pass |
| 156 | 42 | 019 | 0449:41 | | 1335:01<br>1350:00 | 0815.01<br>1335:00 | 0449:41<br>0815:00 | −160.1 | 10 | Power failure and servo problem. Commands late and cancelled due to problem. Station reported TXR noise (spikes on system temp. chart) causing receiver glitches. Special procedure practice for occultation pass |
| | 12 | 019/020 | 2049 | 0821 | 2049<br>2109.48 | 2114:20<br>0450:47 | 0456:34 | −160.2 | 22 | Lunar occultation pass |
| 157 | 42 | 020 | 0442:50 | 1230.00 | 0442:50<br>0450:48 | 0450:48<br>1230 | | −162.0 | 22 | None |
| | 41 | 020 | 0459 | 0640 | | | 0459<br>0513:29<br>0521:19<br>0640:00 | −159.6 | None | Record only |
| | 51 | 020 | 1204 | 2025 | | 1248<br>1344<br>1558<br>1803 | 1204·37<br>1235 | −160.0 | 5 | Pass terminated early (2035) due to station problems in TXR and cables |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 11 | 023/024 | 2103:30 | 0431:00 | 2103:30<br>2104:31 | 2119:20<br>2121:42 | | −160.3 | 0 | Class C test, record only pass. TXR kicked off at 2125:30 and again at 2136:20. Interlock problem. Trouble undetermined |
| | | | | | 2104:40<br>2117:21 | 2126.30<br>2132:00 | | | | |
| | | | | | | 2134:04<br>2142:22 | | | | |
| | | | | | 2142:50<br>2217:10 | | | | | |
| | | | | | | 2218:25<br>0431:00 | | | | |
| | 42 | 023 | 0448 | 1323:57 | 0448<br>0532 | | | −159.9 | 10 | None |
| | | | | | | 0532<br>1323:57 | | | | |
| 161 | 62 | 024 | 1330.20 | 0100:01 | 1330.20<br>1357:22 | 1401:40<br>1409:01 | 2124:25<br>2327:21 | −161.7 | 0 | Calibration pass, no telemetry taken |
| | | | | | | 1410:35<br>2121:40 | | | | |
| | | | | | | 2330:43<br>2331:43 | 0024:55<br>0046:28 | | | |
| | | | | | | 2354:23<br>2356:22 | 0046:30<br>0100.01 | | | |
| | | | | | | 2356:32<br>0014:08 | | | | |
| | 12 | 024 | 2041:38 | 0819:17 | | 2124:20<br>2327:20 | 2041:38<br>2114 | −161.5 | 15 | None |
| | | | | | | 0006:55<br>0441 | 2329<br>2356:07 | | | |
| | | | | | | 0446:15<br>0448:0 | 0000.53<br>0005:50 | | | |
| | | | | | | 0451:52<br>0706:45 | | | | |
| | | | | | | 0707:50<br>0817:08 | | | | |
| | 42 | 024 | 0500 | 1343:30 | 0500<br>0521:21 | 0521:33<br>1330:01 | | −160.0 | 11 | None |
| | | | | | 1333:20<br>1343:30 | | | | | |
| 162 | 51 | 025 | 1200:55 | 2148 | 1200:55<br>1222.45 | 1225:27<br>1506 | 1507<br>1551 | −161.5 | 8 | None |
| | | | | | | 1552<br>2105 | 2106<br>2148 | | | |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 163 | 42 | 026 | 0446 | 1321 | 0446<br>0506:37 | 0507:18<br>0806<br>0811<br>1311:57 | | −160.7 | 12 | TXR drive failure due to receiver-exciter −15-V power supply. Track terminated early as station unable to meet requirements |
| | 62 | 025 | 1356:18 | 0101 | | 1507:00<br>1539.00<br>2117:16<br>0100 | 1356:18<br>1506:10<br>1603.00<br>2059:00 | −161.5 | 0<br>(No capability) | Calibration pass, no telemetry taken |
| | 12 | 026 | 2200 | 2256 | 2200<br>2219:47 | 2221.27<br>2254:55 | | −161.2 | 1 | Special pass. Station called for purpose of putting S/C into duty cycle store. (DSS 42 TXR quit prior to DCS command.) |
| 164 | 62 | 027 | 1331:17 | 0101 | 1331:17<br>1351:00 | 1355:00<br>2115:16<br>2351:20<br>0019:30 | 2115:32<br>2351:20<br>0028:15<br>0101 | −161 2 | 0<br>(No capability) | Special calibration pass, no telemetry recovered |
| | 11 | 027 | 2048:37 | 0424 | | 2132:48<br>2212:50<br>0003:09<br>0015.41<br>0016<br>0422 | 2048:37<br>2114:27<br>2351<br>2357:59 | −161.5 | 14 | CMD 052 sent 4 s early (2255) due to clock jump of 4 s |
| 166 | 51 | 029 | 1207:25 | 2122 | 1207:25<br>1227 | 1232:58<br>2122 | | −162.2 | 25 | The first command (4/100) was initiated at 1240. However, the command was stopped at 1240:19 due to a faulty connector on cable from GOE to TXR |
| 167 | 51 | 030 | 1159:30 | 2119 | 1159:30<br>1229 | 1257<br>2106:21 | | −161.98 | 22 | None |
| | 12 | 030 | 2050 | 0814:12 | | 2121:10<br>0701:01 | 2050<br>2117:38<br>0700:30<br>0814:12 | −161.4 | 23 | None |
| 168 | 42 | 031 | 0512 | 1328:26 | | 0707:50<br>1315 | 0512:18<br>0707 | −161.0 | 17 | None |
| 169 | 42 | 032 | 0445:18 | 1322 | 0445:18<br>0504:02 | 0515<br>1321:28 | | −161.7 | 21 | None |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 170 | 11 | 034 | 0106:43 | 0814 | 0106:43<br>0121:55 | 0125:25<br>0700:01 | 0707:37<br>0814 | −161.9 | 16 | CRUU-4 command late due to operational error. Had time of 0242:32 and gave proper 30-s mark and then transmitted at 0242:42 |
| | 42 | 033 | 0437:51 | 1320 | 0437:51<br>0502:48 | 0509:56<br>1310.01 | 1310:02<br>1320 | −161.5 | 20 | Concern was expressed by the ARC controller in the apparent high parity error in the N-frame printout at 8. This was discussed with Station 42 ARC by means of patch at the completion of pass. During the 3-way with Station 57, 51 showed considerably less parity error than did Station 42. The reason for these anomalies was not determined during the critique |
| | 51 | 033 | 1155:34 | 2118 | 1354:18<br>1410:15<br>1659<br>1711 | 1316<br>1345:30<br>1412:43<br>1655<br>1713.08<br>2115 | 1155:34<br>1316 | −161.98 | 28 | TXR off due to generator power failure. Reset power panel circuit breakers to restore power to TXR |
| 171 | 42 | 034 | 0519:00 | 1300:00 | | 0707:37<br>1257:00 | 0519:00<br>0700.01 | −161.2 | 20 | Station late in ACQ because of problem with high error which required some extra internal checks before acquiring |
| | 11 | 035 | 0057:56 | | 0057:56<br>0115:49 | 0117.33<br>0802.00 | | −163.1 | 21 | None |
| 174 | 11 | 038 | 0102.02 | 0809 | 0102:02<br>0118·40 | 0134.00<br>0700.01 | 0700:02<br>0809 | −162.2 | 15 | None |
| | 42 | 037 | 0525:00 | 1300 | | 0525.00<br>1246:30 | 1246:30<br>1300 | −161.76 | 22 | None |
| | 51 | 037 | 1150:15 | 2110 | | 1246:45<br>2110 | 1150:15<br>1240:44 | −161.9 | 26 | None |
| 175 | 42 | 038 | 0439 | 1127 | | 0709<br>1132:20 | 0439<br>0701 | −162.6 | 9 | None |
| | 51 | 038 | 1148·17 | 2110 | 1148:17<br>1212·41 | 1225:40<br>2110 | | −162 3 | 45 | Lost voice communication at 1755. Command at 1800 sent as scheduled; however, station held up on command transmission at 1800:30 as Goddard called on circuit at 1800:25, and was assumed by station to be net control calling to hold off sending commands. Correct command sequence sent at 1804 30 and 1805. Voice communications returned at 1802 |

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) 1-way | 2-way | 3-way | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 176 | 11 | 040 | 0050 | 0807 | 0050<br>0123.20 | 0126:20<br>0645.01 | 0646:20<br>0807 | −161.7 | 13 | None |
| | 42 | 039 | 0444:30 | 1303:23 | 0444:30<br>0458:23 | 0500:10<br>1303 | | −161.7 | 24 | Various receiver glitches were noted throughout the pass at 16 bits/s. While at 16 bits/s, there were many limit checks beyond limits. Changed to 8 bits/s at 06081:48. No glitches noted after this until 0705:01 |
| 177 | 42 | 040 | 0438 | 1311 | | 0653<br>1246.57 | 0438<br>0645<br>1246·57<br>1311:00 | −163 6 | 13 | Station reported throughout the pass various signal level changes and receiver glitches on transfers from DSS 11 to DSS 42 and DSS 42 to DSS 51. At one point the temperature rose abruptly 9 deg and at the same instant, 1038, the signal level increased from 163.5 to 161.9. At 1045 the signal level decreased to 163.5 and the temperature decreased by 9 |
| | 51 | 040 | 1150 05 | 2105 | 1328<br>1359·50 | 1247:00<br>1325.50<br>1404:43<br>2105:00 | 1150:05<br>1245:48 | −162.7 | 17 | None |
| 178 | 42 | 041 | 0433 | 1300 | 0433<br>0455:06 | 0456:48<br>0457:14<br>0500<br>1300 | | −163.3 | 20 | Station had receiver glitches from 1110:12 to 1200. Receiver 1 was reconfigured to channel 7, and the signal level compared favorably. Glitches still occurred, however, on receiver 1 but at different times than receiver 2. Both receivers are on the same maser. A random 1 dB variation on AGC was noted on both the Sanborn recorder and digital voltmeter. During this time, DSS 51 stated signal level was steady on −163.5 dB. At end of track, station switched masers and picked up the S/C again, but the signal was quite weak, with many glitches. Nothing determined as to cause |
| | 51 | 041 | 1144:10 | 2103 | | 1257:05<br>2102:00 | 1144:10<br>1257:05 | −162.8 | 23 | None |
| 179 | 42 | 042 | 0432:44 | 1255 | 0432:44<br>0457:58 | 0459:32<br>1255:00 | | −162.8 | 26 | None |

## Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 180 | 42 | 043 | 0431:15 | 1254 | 0431:15<br>0452:34 | 0454:56<br>1248 | | −162.3 | 26 | None |
| | 11 | 043 | 2026:21 | 0750:00 | 2026:21<br>2039·58 | 2046:45<br>0750.00 | | −162.2 | 39 | None' |
| 181 | 51 | 044 | 1147:11 | 2100 | 1147:11<br>1204:08 | 1216:02<br>2057:33 | | −162.8 | 27 | None |
| | 11 | 044/045 | 2320:10 | 0526:00 | 2320:10<br>2338:00 | 2338:00<br>0500:01 | 0500:01<br>0526:00 | −161.8 | 16 | Solar flare pass |
| 182 | 42 | 045 | 0426 | 1300 | 0426<br>0516 | 0517<br>1245:01 | 1246<br>1300 | −162.8 | 25 | None |
| | 51 | 045 | 1139 | 2105 | | 1253<br>1305<br>1308<br>2105 | 1139<br>1250 | −162.7 | 35 | None |
| | 11 | 045 | 2025:33 | 0801 | | 2107:15<br>0737:17 | 2025.33<br>2107:15<br>0740.01<br>0801 | −162.5 | 38 | None |
| 183 | 42 | 046 | 0700 | 1300 | | 0748:57<br>1250:07 | 0700:00<br>0740<br>1250:08<br>1247:21 | −163.0 | 7 | None |
| | 51 | 046 | 1145.03 | 2100 | 1301<br>1310:44 | 1318:31<br>2100 | 1145:03<br>1247 | −163. | 27 | None |
| 184 | 42 | 047 | 0428:01 | 1300 | 0428.01<br>0443.40 | 0444:32<br>0433:06<br>0638:50<br>0461:00<br>0644:30<br>1230 | 1236:40<br>1300 | −162.5 | 29 | Beta computer inadvertently turned off, causing the alpha computer to drive antenna off the S/C |
| | 51 | 047 | 1136:35 | 2049 | | 1235:55<br>2049 | 1136:35<br>1230 | −163.5 | 36 | CMD 051 sent early due to operator error |
| 185 | 42 | 048 | 0442:40 | 1300 | 0442:40<br>0457 | 0503:55<br>1250:16 | 1252.51<br>1300:00 | −162.5 | 22 | None |
| | 51 | 048 | 1146 | 2051 | | 1251·40<br>2051 | 1146<br>1247 | −163.4 | 18 | None |
| 186 | 42 | 049 | 0424:55 | 1256 | 0424:55<br>0442:04 | 0443.10<br>1237:02 | 1237:02<br>1256.00 | −162.8 | 17 | None |
| | 51 | 049 | 1143:28 | 2055 | | 1238:02<br>2055 | 1143:28<br>1237:02 | −164.2 | 26 | None |
| 187 | 42 | 050 | 0433:20 | 1250:00 | 0433:20<br>0452:50 | 0500:20<br>1248:00 | | −152.4 | 21 | None |

Table 18 (contd)

| Pass | DSS | Day of year, GMT | Acquisition of signal, GMT | End of track, GMT | Ground modes (Start and end times, GMT) | | | Received signal strength, dBmW | Number of commands | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-way | 2-way | 3-way | | | |
| 188 | 42 | 051 | 0427:10 | 1245 | 0427:10<br>0443:17 | 0501:55 | | −163.0 | 20 | None |
| 189 | 42 | 052 | 0422:45 | 1253 | 0422 45<br>0444 | 0451:06<br>1208·00 | 1208.00<br>1253:00 | −162.0 | 15 | None |
| | 51 | 052 | 1141.00 | 2107 | | 1208:00<br>1225:34<br>1228:01<br>2058 | 1141:00<br>1208·00 | −163.1 | 21 | None |
| | 14 | 052/053 | 2206:41 | 0458:00 | 2111:15<br>2112:38 | 2112:56<br>0458:00 | 2206:41<br>2209.59 | −154.8 | 6 | Solar flare pass |
| 190 | 42 | 053 | 0422:35 | 1254.00 | 0430 | 0534·25<br>0534·25<br>1254:00 | 0422:35<br>0433:22 | −162.9 | 11 | Solar flare pass |
| | 51 | 053 | 1134:45 | 2044 | | 1232·30<br>2043 | 1134:45<br>1232:30 | −163 6 | 22 | Total receiver glitches are 143 |
| 191 | 42 | 054 | 0425:51<br>0433:46 | 1245 | 0425<br>0523 | 0524<br>1243 | | −163.45 | 17 | None |

*4. Space Flight Operations Facility.* The SFOF provided all necessary services, functions, and equipments to make a very successful launch possible for *Pioneer VII*. The FPAC team started its computation of the parking orbit, which had been nominal at 35 min after launch, as a backup computation to the AFETR activity. The deviation between the AFETR and JPL parking orbits was within the required accuracy limits. The computation of the solar orbit started 1 h after launch, utilizing two-way tracking data from Stations 51 and 42. The first solar orbit, called the PROR orbit, was available approximately 2 h after launch and was used to generate immediately new predicts for the DSIF stations. Three more orbits were generated within 20 h after launch, utilizing two-way tracking data of Stations 51, 42, and 11. The second, third, and fourth orbits were very close, and the fit to the available data has been almost perfect.

All orbit and predicts computations necessary to have a successful launch operation were performed on the W string at the SFOF. In accordance with the original plan, it was not possible to provide a backup computer for the *Pioneer VII* launch because of the high-level activities of the *Lunar Orbiter* Project. Nevertheless, it was possible a few hours prior to the *Pioneer VII* launch to rearrange the loading of the three computer strings in such a manner that the *Lunar Orbiter* Project Office was making available to *Pioneer* one of its computer strings as the backup to the W string. Fortunately, the W string operated reliably and, therefore, there was no need to go back to the backup computer. Subsequent launches have been scheduled in such a way that every project should have available during launch an operational and backup computer string in order to insure the computer reliability necessary.

N70-28136

## VI. *Pioneer VII* TDS Performance Evaluation

### A. Near-Earth Phase

*1. Air Force Eastern Test Range.* It can be stated that the elements and facilities of the near-earth phase supported *Pioneer VII* with an outstanding performance. The following information provides some understanding of how the above was accomplished.

The requirements documents stated that the S-band telemetry center frequency was 2292.037 MHz. At launch minus two days the *Pioneer* Project submitted a new frequency of 2292.017 MHz, a decrease of 20 kHz. Since AFETR stations did not have crystals for the new frequency, special instructions had to be prepared and sent

downrange for tuning to the lower frequency. If the frequency change had been greater than 40 kHz, AFETR in all probability would not have been able to support the S-band telemetry requirements since the S-band receivers have a tuning capability of only ±120 kHz, ±80 kHz of which is needed for doppler tuning.

The AFETR count was issued on launch minus 1 day. This count is based on the range user count, which is presently required by $L - 5$ days. Since this lead time makes it difficult to issue the AFETR count on $L - 3$ days, it was suggested that the range user milestone count be required at $L - 7$ days, with the detailed count required at $L - 5$ days.

Apparently sufficient information can be provided by the range user at $L - 7$ days to allow AFETR to compile its countdown.

The spacecraft, launch vehicle and experiment prelaunch operations were performed nominally, generally ahead of the countdown. The countdown for prelaunch operations appeared to be moving smoothly toward a 6-min launch window (1518 to 1524 GMT) on August 17, 1966. At $T - 1$ h 40 min, DSS 51 reported the station transmitter out. Analysis and repair brought the transmitter to a high of 3 kW for possible acquisition. All repairs were made without a hold in the countdown relative to this problem. Tower removal was delayed at Pad 17A. However, the count continued to liftoff at 1520:17 GMT.

*a. Tracking.* The near-earth tracking coverage performed by AFETR is given in Table 19. Table 20 lists the sequence of near-earth *mark* events. As can be noted from Fig. 50, the near-earth tracking coverage was adequate, with no dropouts, although some gaps in coverage are evident. The spacecraft separation *mark* event was not read out because of operator error aboard RIS *Sword Knot.*

**Table 19. AFETR tracking coverage**

| Station | Acquisition of signal, GMT | Loss of signal, GMT |
|---|---|---|
| DSS 71 | Liftoff | 1523 |
| Grand Bahama | 1521 | 1531 |
| Antigua | 1527 | 1533 |
| *Sword Knot* | 1541 | 1546 |
| DSS 72 | 1542 | 1549 |
| Pretoria | 1550 | 1601 |

**Table 20. Near-earth phase *mark* events**

| Mark | Event | Nominal time from liftoff, s |
|---|---|---|
| 0 | Liftoff | $L +$ 0 |
| 1 | Thrust-augmentation rocket jettison | $L +$ 70.00 |
| 2 | MECO | $L +$ 149.521 |
| 3 | Second-stage ignition | $L +$ 153.521 |
| 4 | Shroud jettison | $L +$ 175.521 |
| 5 | SECO | $L +$ 530.321 |
| 6 | Third-stage spin-up | $L +$ 1475 521 |
| 7 | Second-stage/third-stage separation | $L +$ 1477.5 |
| 8 | Third-stage ignition | $L +$ 1490.521 |
| 9 | Third-stage burnout = injection | $L +$ 1521.341 |
| 10 | Third-stage/spacecraft separation | $L +$ 1586.521 |

Real-time doppler was received only from the KSC satellite tracking station. Antigua doppler was degraded due to the single-sideband transmission. Ascension doppler data was not available.

*b. S-band telemetry.* As can be seen from Fig. 51, AFETR provided considerable S-band support. In general, the AFETR S-band systems covered a total of 455 s out of the required 600 s of class I data. Table 21 gives the AFETR S-band coverage for *Pioneer VII.* Figure 51 graphically depicts the individual S-band coverage by station for *Pioneer VII.*

An unexplained 20-dB excess gain was apparent in the early launch phase. Something less than this was apparent in the latter launch phase. This matter has been under joint NASA/AFETR investigation.

The P-band telemetry and radar coverage was as expected. The S-band telemetry system covered a total of 455 s out of a required 600 s of class I data. The primary coverage loss occurred at Antigua, which experienced numerous receiver lock/unlock indications. Antigua was operating under a limited data commitment owing to lack of final acceptance of the system.

Third-stage/spacecraft separation was not read out by *Sword Knot,* through the S-band telemetry signal, because of a local operator error in handloading the time division multiplex (TDM) program. This problem was

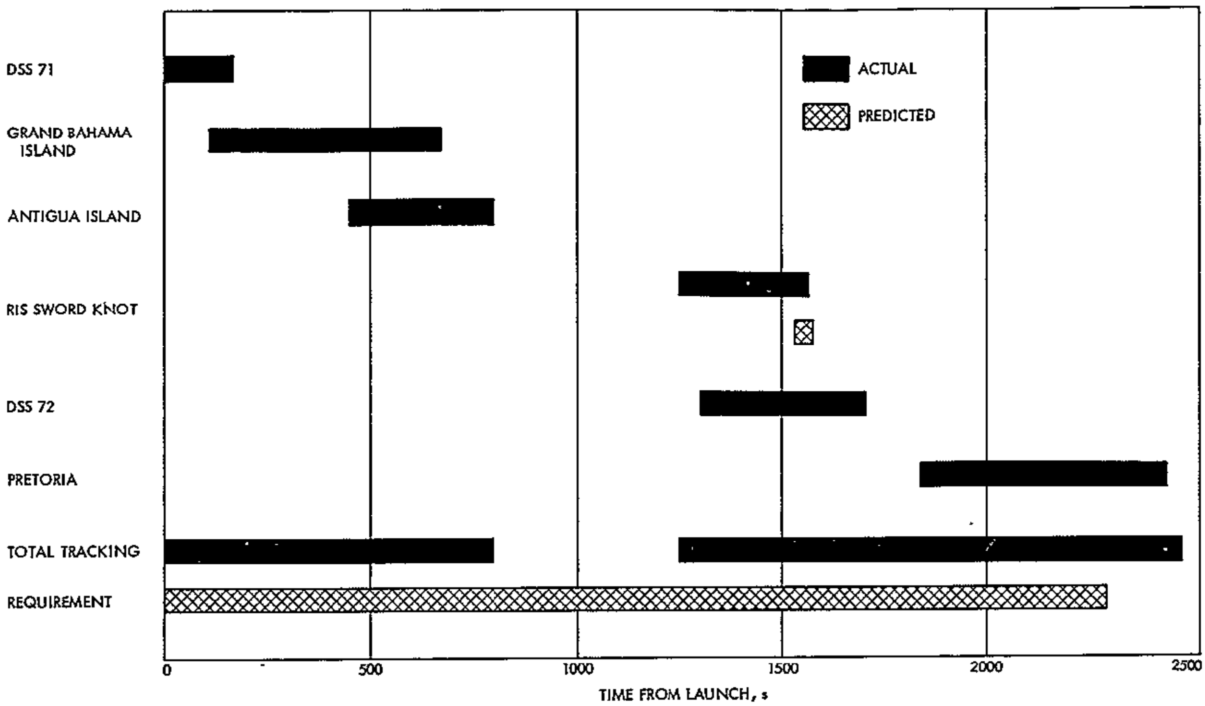


Fig. 50. *Pioneer VII* AFETR tracking coverage

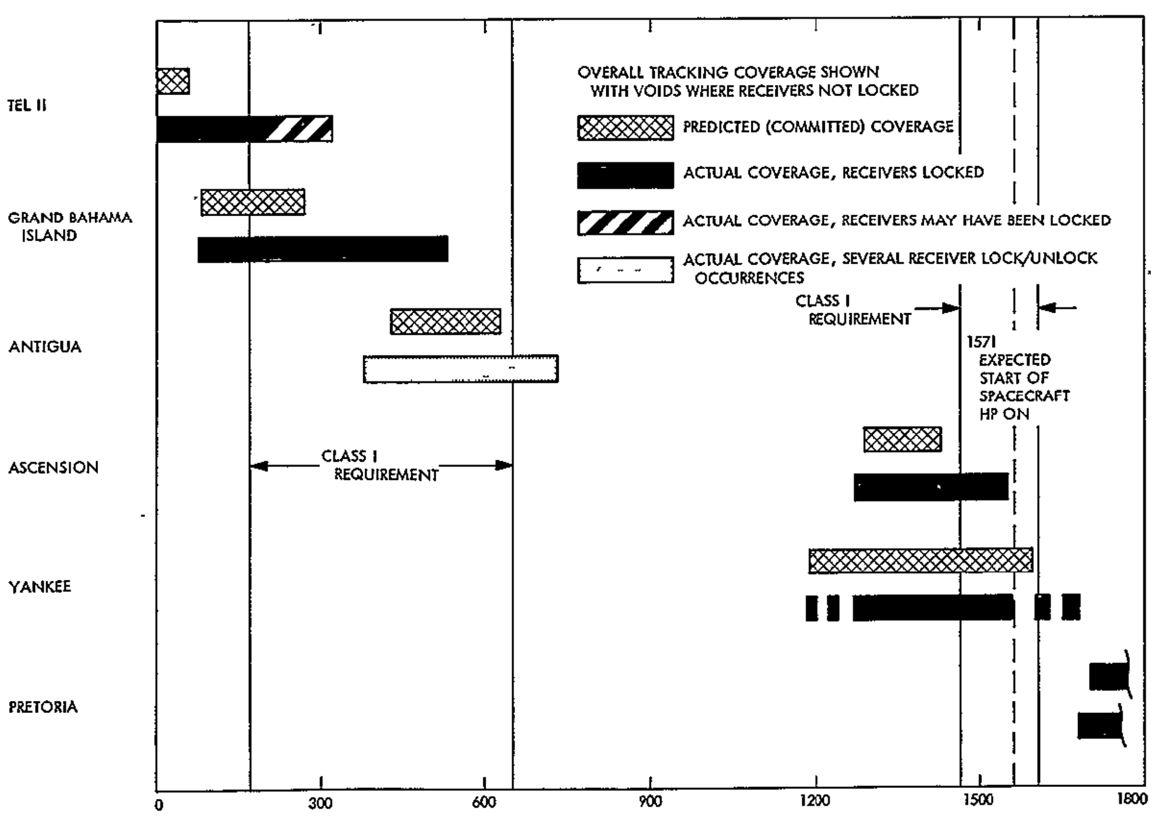


Fig. 51. *Pioneer VII* AFETR S-band coverage

Table 21. AFETR S-band coverage

| Station | Predicted tracking interval, s | Actual tracking interval, s | Interval during which receivers are locked, s |
|---|---|---|---|
| Tel 2 | −180 to +320 | −185 to +320 | −185 to +320 (TDM-1 lost lock at −180) |
| Grand Bahama | −86 to +272 | −74 to +529 | −74 to +529 |
| Antigua | +420 to +620 | +383 to +517<br>+659 to +738 | (Several lock/unlock occurrences due to interference) |
| Ascension | +1280 to +1430 | +1263 to +1553 | +1263 to +1553 |
| *Sword Knot* | +1190 to +1602 | +1181 to +1688 | +1181 to +1688 |
| Station 13 | Initiation of track at +1721 | +1683 to +3610 | +1683 to +3610 |

aggravated by the fact that *Sword Knot* did not receive the OD instructions for loading the TDM program until $L - 1$ day. As a result, the class I telemetry data requirement was not met by *Sword Knot.*

As corrective action, improved procedures were instituted. A simulation tape of nominal data was to be provided, pretested, and used to check-test planning and test configuration.

The S-band antenna at Tel 2 started to bind a number of times during the launch. This binding had been a problem on previous launches and was expected. An operator had been placed near the antenna to manually free the pivot whenever the binding was observed. Since the *Pioneer* launch, the elevation bearings have been replaced. This has not, however, corrected the problem.

*c. VHF telemetry.* All VHF telemetry commitments were met (see Fig. 52). The class II VHF orbital telemetry support was also provided. *Pioneer VII* received carrier power signal strength is shown in Fig. 53.

*d. Real Time Computer System.* The RTCS support was considered good. There were no major anomalies or breakdowns. AFETR/RTCS was requested to provide look angles for the NASA/GSFC stations at Hawaii and Carnarvon. GSFC did not choose to use the AFETR angles even though the first set of GSFC-generated angles was in error. The range user was asked why the AFETR-generated look angles were not used. The answer was that the AFETR angles are used as backup only when GSFC does not have the capability or enough time remaining to generate its own look angles.

*e. Communications.* Some pad problems were experienced. At 0 − 15 min, a power failure at Grand Bahama caused a loss in AFETR voice nets. Antigua doppler data was switched from the subcable to single sideband. This failure resulted in a 2-min hold at $T - 5$ min for confirmation that Station 7 and/or 9 metric data would be provided to insure that class I requirements would be met.

*2. Manned Space Flight Network.* The MSFN configuration in support of the *Pioneer VII* mission performed satisfactorily. Table 22 summarizes MSFN support for *Pioneer VII.* The network was controlled from the GSFC/MSFN operations center.

*a. Radar.* The C-band radars at Bermuda, Carnarvon, and Hawaii tracked the *Delta* beacon from AOS to LOS for two orbits or approximately launch plus 200 min. No signal was heard on the third revolution. Radar phasing control for Bermuda was provided by the AFETR. The following stations were scheduled to track the C-band beacon of the *Delta* vehicle, record data on magnetic tape, and transmit data in real-time to GSFC and the AFETR RTCF (Bermuda only):

| | Revolution |
|---|---|
| Bermuda | 1 |
| Carnarvon | 1 and 2 |
| Hawaii | 1, 2, and 3 |

Table 22. MSFN station configuration

| Station | C-band radar | Acquisition aid | Telemetry | Revolution |
|---|---|---|---|---|
| Bermuda | X | X | X | 1 |
| Tananarive | | X | X | 1 and 2 |
| Carnarvon | X | X | X | 1 and 2 |
| Guam | | X | X | 1 and 2 |
| Hawaii | X | X | X | 1 and 2 |

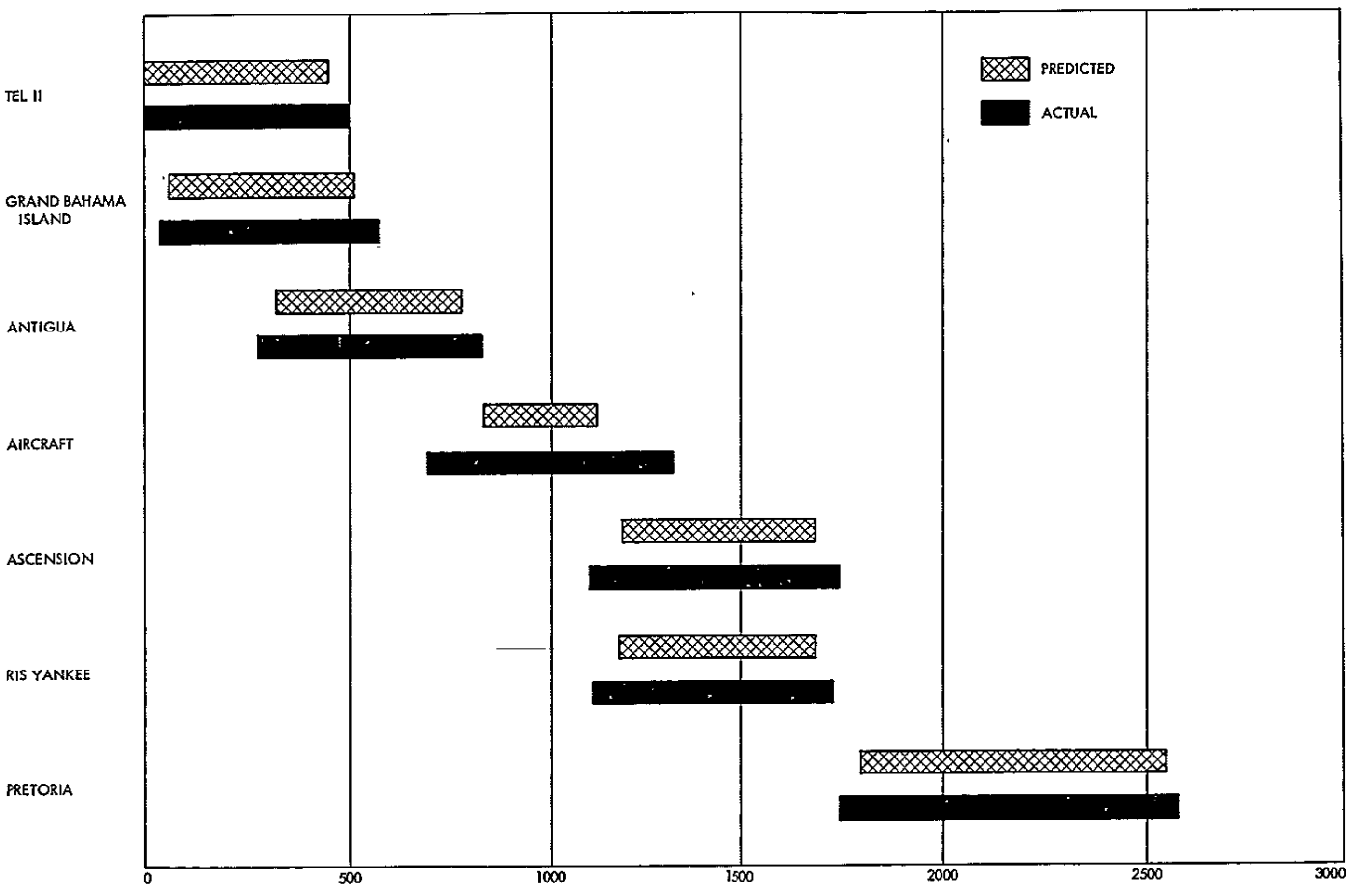


Fig. 52. *Pioneer VII* AFETR VHF telemetry coverage

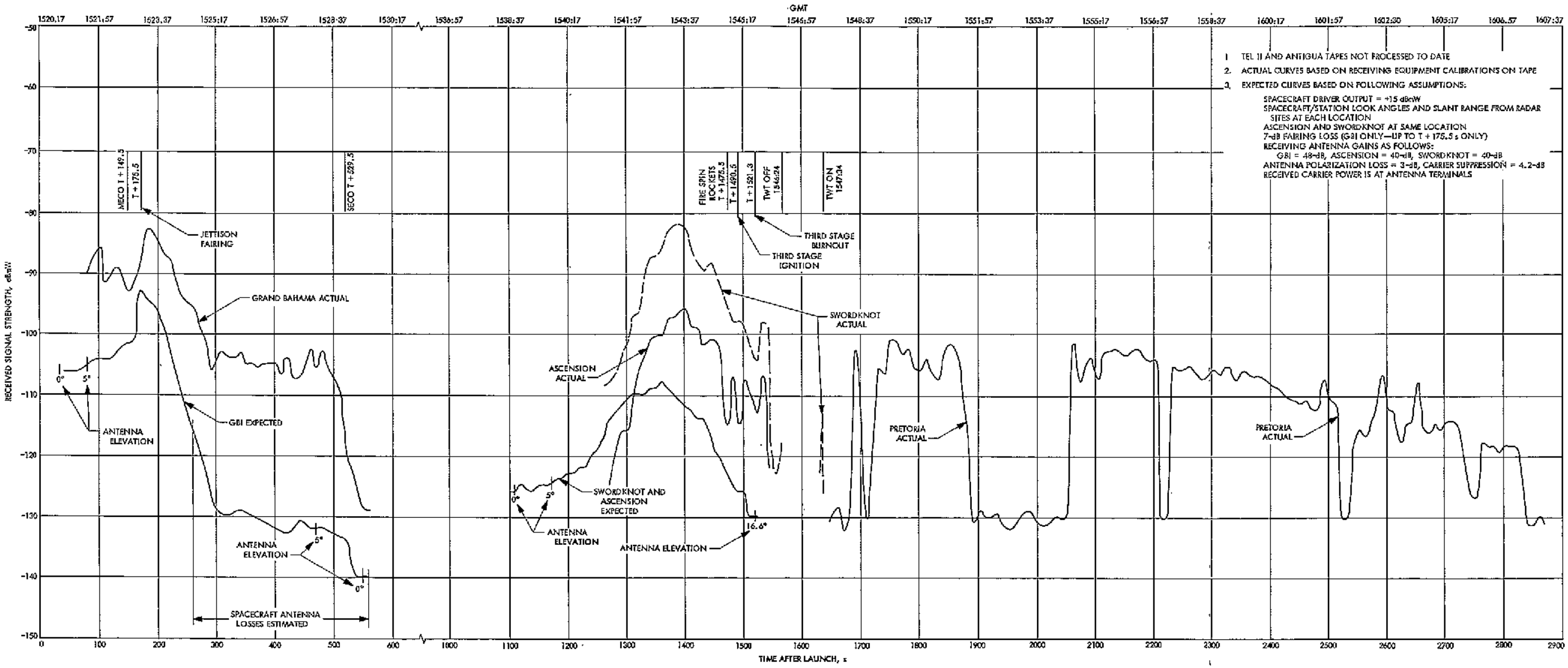


Fig. 53. *Pioneer VII* near-earth phase received carrier power

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Radar systems support during the *Pioneer VII* mission was generally excellent. No equipment malfunctions were encountered. Carnarvon reported that during revolution 1 the beacon signal faded shortly after the point of closest approach, apparently due to the vehicle attitude. Table 23 shows the radar coverage for the *Pioneer VII* mission.

*b. Telemetry.* The acquisition aids at Bermuda, Guam, Hawaii, Tananarive, Carnarvon, and the KSC station at WTR tracked the second-stage *Delta* telemetry link and provided RF inputs to the telemetry system and steering inputs to the radar antennas where applicable. Telemetry data was recorded for two revolutions from AOS to LOS. No signal was heard on the third revolution. The following stations were scheduled to receive and record the *Delta* second-stage telemetry link (234.0 MHz):

| | Revolution |
|---|---|
| Bermuda | 1 |
| Hawaii | 1, 2, and 3 |
| Tananarive | 1, 2, and 3 |
| Carnarvon | 1 and 2 |

All stations reported that telemetry systems support was excellent; no major problems were encountered. No equipment malfunctions were reported. Table 24 shows the telemetry coverage for *Pioneer VII.*

Acquisition aids were used to provide RF inputs to the telemetry receivers and steering inputs to the radar antennas. Acquisition aid performance was as planned, with one exception. Bermuda acquisition aid 3 performed erratically owing to a defective servo gain potentiometer in the output of the servo buffer.

*c. Computers.* Real-time transmission of radar data to GSFC/Data Operations Branch (DOB) from the various sites made available to the network updated acquisition information on a timely basis.

*Prelaunch phase.* The GSFC DOB was scheduled to (1) prepare and transmit nominal pointing data for the *Delta* vehicle to Bermuda, Tananarive, Carnarvon, Hawaii, and Guam, (2) conduct computation and data flow integrated subsystem testing with the C-band radars at Bermuda, Carnarvon, and Hawaii during the

**Table 23. MSFN radar coverage**

| Station | Revolution | Total autotrack, s | Predicted on-horizon, GMT | Predicted off-horizon, GMT | Acquisition of signal, GMT | Acquisition of signal range, kyd | Loss of signal, GMT | Loss of signal range, kyd |
|---|---|---|---|---|---|---|---|---|
| Carnarvon FPQ-6[a] | 1 | 714 | 1609:14 | 1627:20 | 1609:15 | 3822 | 1624:57 | 3142 |
| Carnarvon FPQ-6[a] | 2 | 837 | 1754:11 | 1808:08 | 1754:12 | 3895 | 1808:09 | 3926 |
| Hawaii FPS-16[a] | 1 | 630 | 1640:36 | 1653:40 | 1642:28 | 2815.7 | 1653:28 | 2659.2 |
| Hawaii FPS-16[a] | 2 | 408 | 1825:46 | 1835.56 | 1829:10 | 1885.6 | 1835:58 | 2414 3 |

[a]Beacon tracking mode

**Table 24. MSFN telemetry coverage**

| Station | Revolution | Predicted on-horizon, GMT | Predicted off-horizon, GMT | Acquisition of signal, GMT | Loss of signal, GMT | Total dropouts, s | Total track, s | Frequency, MHz |
|---|---|---|---|---|---|---|---|---|
| Bermuda | Launch | 1523:17 | 1530.47 | 1523:10 | 1531:02 | 0 | 472 | 234.0 |
| Tananarive | 1 | 1551:13 | 1607:42 | 1554:42 | 1607:43 | 0 | 781 | 234.0 |
| Tananarive | 2 | 1737:26 | 1752:59 | 1737:35 | 1753:10 | 0 | 935 | 234.0 |
| Carnarvon | 1 | 1609:14 | 1627:20 | 1609.05 | 1627:48 | 0 | 1123 | 234.0 |
| Carnarvon | 2 | 1753:47 | 1808:08 | 1753·29 | 1808:33 | 0 | 904 | 234.0 |
| Hawaii | 1 | 1640:58 | 1653:40 | 1639.35 | 1653:58 | 0 | 863 | 234.0 |
| Hawaii | 2 | 1825:46 | 1835:56 | 1824:54 | 1836:25 | 0 | 681 | 234.0 |

terminal countdown, and (3) conduct high-speed interface tests with the Cape Kennedy impact predictor 3600 computer during the terminal countdown.

*Launch phase.* The GSFC computers were to receive launch trajectory data from the AFETR stations and to compute trajectory. The resulting parameters were to be used to drive displays at the mission control center at Cape Kennedy and at GSFC.

*Orbital phase.* The DOB was to transmit acquisition messages to participating MSFN stations at $H - 25$ and $H - 5$ min until battery depletion occurred aboard the *Delta* vehicle.

*d. Ground communications.* The NASA Communications Network was scheduled to provide voice, teletype, and high-speed data circuits. The NASCOM facilities were used to provide voice and teletype support for the *Pioneer VII* mission. All circuitry performed satisfactorily except as indicated below. The ground communications network which was used to support the *Pioneer VII* mission is illustrated in Fig. 54.

*Tananarive.* The Tananarive voice circuit was intermittently weak, but readable, throughout the entire mission.

*Carnarvon.* Both voice and teletype communications were lost with Carnarvon a short time prior to launch. Voice communication was restored after 3 min, and teletype service was restored after an outage of 10 min. Both voice and teletype circuits were operational at launch time and performed satisfactorily throughout the remainder of the mission. Carnarvon stated that the circuit difficulties lay between the station and Sydney, Australia.

*Hawaii.* The Hawaii teletype circuit failed just prior to the third pass of the vehicle, but was restored within a few minutes. The reason for this outage was unknown.

*e. Data handling.* Table 25 indicates the data recorded and shipped by the supporting MSFN stations to the GSFC data services group. Except as noted, the data was received within acceptable time frames and in good condition.

*Incoming data.* Data shipments from Tananarive were not received by the data services group until September 19, 1966 (33 days after mission termination). No date of transmittal was listed on the data log, nor was a teletype message received by the group advising when to expect this shipment. All other data was received in good condition with no delays.

**Table 25. Data received for the *Pioneer VII* mission**

| System | Bermuda | Carnarvon | Guam | Hawaii | Tananarive |
|---|---|---|---|---|---|
| Radar | | | | | |
| Magnetic tape | a | 2 | | 1 | |
| Operator logs | | 2 | | 2 | |
| Strip charts | | 1 | | 2 | |
| Telemetry | | | | | |
| Magnetic tape | 1 | 2 | 2 | 4 | 4 |
| Strip charts | 1 | 2 | | 1 | 1 |
| Operator logs | 1 | 2 | 2 | 2 | 3 |
| Acquisition aids | | | | | |
| Strip charts | 1 | | | | |
| Operator logs | 3 | 4 | 2 | 4 | 3 |

aRadar magnetic tapes from Bermuda are recorded directly at GSFC.

*Outgoing data.* Data shipments to requesting agencies were made without delay, except for those from Tananarive.

*Total acquisition support.* Table 26 lists predicted vs actual coverage times.

*Support provided.* The MSFN participated in one mission simulation on August 16, 1966. All MSFN stations were "green" for launch and participated without any problems.

*Support deficiency.* No problems were encountered during the near-earth orbit phase of the mission. However, late receipt of support requirements created hardships on MSFN personnel and facilities. This was remedied somewhat by transmitting the network operations plan via teletype, a procedure that should be resorted to only in emergencies.

*Problems.* It was requested that timely inputs be received at least 45 days in advance to allow for planning and organizing of MSFN supporting facilities.

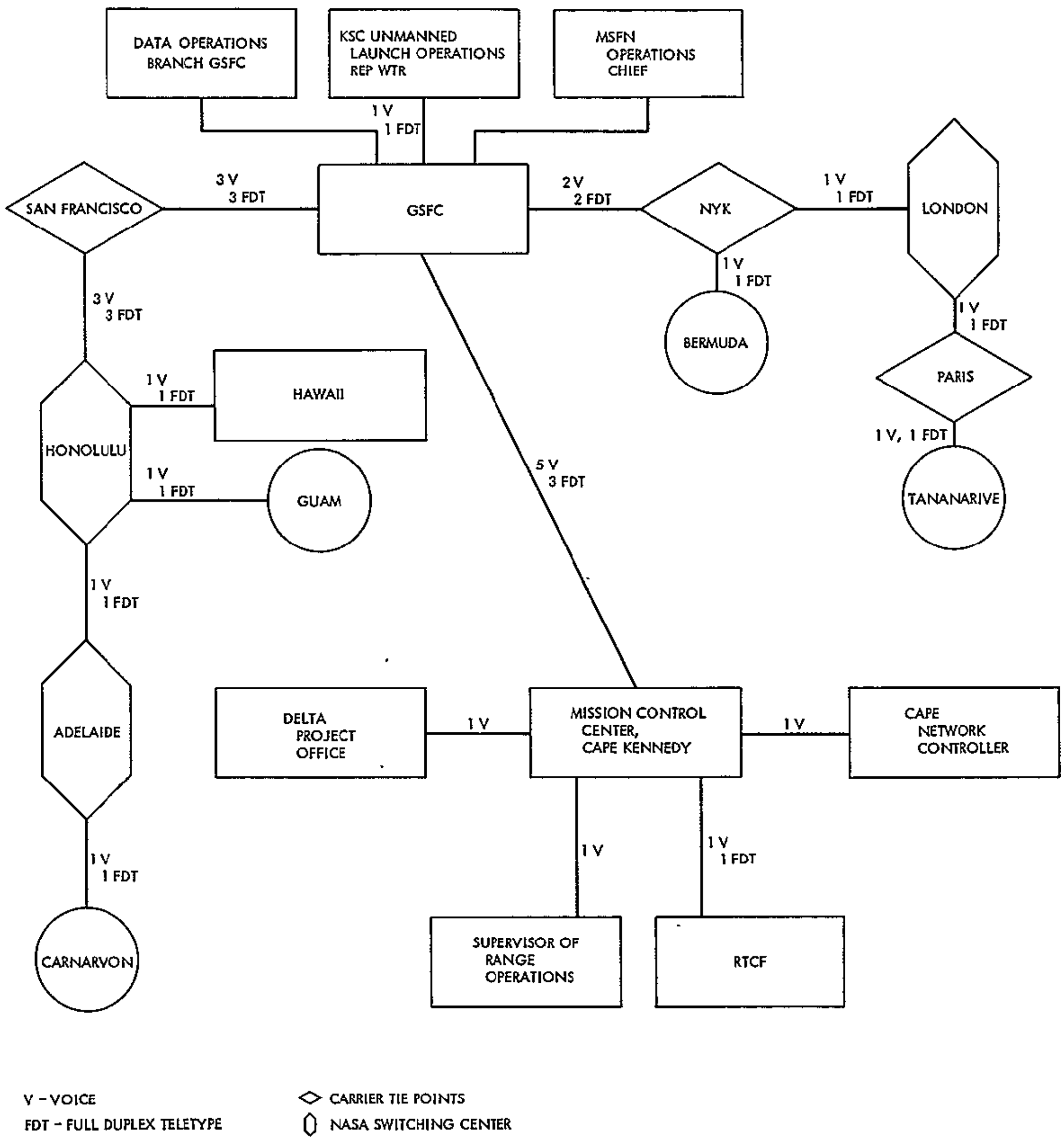


**Fig. 54. MSFN ground communications configuration**

Table 26. MSFN predicted vs actual coverage

| Station | Revolution | Predicted on-horizon, GMT | Predicted off-horizon, GMT | Acquisition of signal, GMT | Loss of signal, GMT | System |
|---|---|---|---|---|---|---|
| Hawaii | 1 | 1640:36 | 1653:40 | 1642:28 | 1653:28 | Radar |
| Hawaii | 2 | 1825:46 | 1835:56 | 1829:10 | 1835:58 | Radar |
| Carnarvon | 1 | 1609:14 | 1627:20 | 1609:15 | 1624:57 | Radar |
| Carnarvon | 2 | 1754:11 | 1808:08 | 1754:12 | 1808:09 | Radar |
| Hawaii | 1 | 1640.58 | 1653:40 | 1639:35 | 1653:58 | Telemetry |
| Hawaii | 2 | 1825.56 | 1835:56 | 1824:54 | 1836:25 | Telemetry |
| Tananarive | 1 | 1551:13 | 1607:57 | 1554:42 | 1607:43 | Telemetry |
| Tananarive | 2 | 1737:26 | 1752:59 | 1737:35 | 1753.10 | Telemetry |
| Carnarvon | 1 | 1609:14 | 1627:20 | 1609:05 | 1627:48 | Telemetry |
| Carnarvon | 2 | 1753:47 | 1808:08 | 1753:29 | 1808:33 | Telemetry |
| Guam | 1 | 1624:00 | 1640:10 | 1624 04 | 1640.42 | Telemetry |
| Guam | 2 | 1807:57 | 1823:57 | 1807:10 | 1823:23 | Telemetry |
| Bermuda | 0 | 1523:17 | 1530:47 | 1523:10 | 1531.02 | Telemetry |

3. *Deep Space Network.* On August 17, 1966, the first entry was at $T - 130$. It was reported that DSS 51 was in the red as the transmitter kept going off. Stations 42, 71, and 11 were in the green. The $L - 340$-min frequency report from DSS 71 was 2292.017759 MHz. The temperature was 72.27°F. Flight TDA supplied a frequency for DSS 51 for the VCO which was 21.985760 MHz. The frequency for 42 was 21.985400 MHz.

The $T - 100$ frequency report from DSS 71 was 2292.016604 MHz at 79.04°F. The problem DSS 51 experienced was as follows: There was an arcover in the transmitter power supply due to an insulation breakdown in the high-voltage rectifier section. According to their analysis apparently one of the three phase rectifiers was bad.

At $T - 45$, DSS 51 continued to report they were in the green except for the transmitter problem. The $T - 100$ frequency report from DSS 71 date/time group 17/1325 was 2292.015852 MHz at 81.43°F. In case of an emergency where DSS 51 did not have uplink power, the turn-on time for DSS 42 was to be plus 52 min and their frequency offset 5450 Hz. At $T - 45$, the frequency report was 2292.015811 MHz at 8143°F. Station 51 finally reported it was capable of acquiring, but with limited power of 3 kW.

The prelaunch frequency message sent at 1432 GMT was as follows:

$$FA = 2292.017582 \text{ MHz}$$

$$FB = 21.985233 \text{ MHz}$$

$$K1 = 23.566300 \text{ MHz}$$

At $L - 16$ the offset frequency given to the stations was 5775 Hz. The instructions which went to DSS 51 were that the transmitter would turn on at $L + 35$ and the synthesizer frequency which had been established for $L + 35\frac{1}{2}$ minutes was 5790 Hz. They were to hold this frequency until $L + 37$.

The following signal levels were reported from DSS 71:

Liftoff at 94 dBmW.

−115 dBmW at 1 min 27 s.

−116 dBmW at 1 min 37 s.

115 dBmW at 1 min 40 s.

−117 dBmW at 1 min 50 s.

−119 dBmW at 2 min.

−118 dBmW at 2 min 10 s.

−124 dBmW at 2 min 20 s.

130 dBmW at 2 min 30 s.

−129 dBmW at 2 min 40 s.

−129 dBmW at 2 min 50 s.

−139 dbm at 3 min.

Lock was lost by DSS 71 at launch plus 3 min 10 s. Grand Bahama subsequently acquired within seconds. The AGC signal level readings were given on 10-s intervals.

Nominal predicts based on DSS 71 frequency measurements for acquisition by DSS 72 were used at DSS 51. Antigua lost lock at 14:40 GMT.

Receiver 2 at Ascension was in lock at 1540:15 GMT at a frequency of 70.06618 MHz with signal strength of −143 dBmW. Receiver 1 was in lock at 1541:30 GMT with signal strength of −103 dBmW and frequency 70.064618 MHz. Ascension dropped lock at 1547:00 GMT.

Station 72 started in autotrack on the SCM immediately after receiver 1 locked up. The receiver was in lock at DSS 51 at $L + 2820$ s; boom was deployed; TWT 2 was on, $-121$ dBmW, and improving. At $L + 2910$ s the spacecraft was operating correctly.

Station 51 was in autotrack at 1549:40 GMT, which was approximately $L + 2940$ s. Signal strength was $-133$ dBmW at $L + 3440$ s. The receiver went out of lock at $L + 3556$ s. Two-way lock was acquired at 1557:20 (equivalent to $L + 3710$ s) on sideband with the receiver in lock at 1557:41 GMT. Two-way lock was confirmed at $L + 3748$ s; at about 1602 GMT they went SCM apparently without reducing spacecraft SPE to zero. Two-way lock was lost at 21.985769 MHz.

At 1610:52 GMT, DSS 51 again acquired two-way lock. The signal strength at 1602 GMT was $-98$ dBmW; it was going down steadily until at 1627 it was $-100$ and at 1612 was $-101$ dBmW. At 1620 the signal strength was $-107$ dBmW. At 1621 it dropped rapidly to $-115$ dBmW. Station 51 transferred lock to DSS 42 at 1625:30. The station transfer was early. Station 51 lost lock because of prelimits on the antenna. Apparently there was a hot third-stage burn and low trajectory causing the spacecraft to dip over the horizon sooner and farther than anticipated.

Station 42 was receiving but was not in two-way lock. There was no uplink lock at 1 h 7 min, or 1627 GMT. At 1632, DSS 42 lost lock on the downlink. Verification of two-way lock was performed at 1632 or 1 h 14 min from launch. The receiver frequency was 5774 MHz at this time. Station 42 retuned to syn freq at 5422 MHz. Station 42 was still tracking; the telemetry was reading a 6.6 kHz negative SPE. No SPE reduction was performed.

At 1 h 41 min after receiving launch, DSS 42 was expecting to transfer at 1930 GMT back to DSS 51. A possible explanation for the early limit on DSS 51 was that the spacecraft third-stage burn was hotter than expected and caused this problem. At 1702 the SPE dropped down to $-3.3$ kHz. The spacecraft went into the earth's shadow at 1706. Station 51 reported the spacecraft was coming back into limits at 1713, or 1 h 53 min past launch. During the period that the spacecraft was in the earth's shadow, the battery voltage was noted to be dropping slightly, as would be expected. Station 51 was on autotrack, SCM at 1727 or 2 h 7 min after launch.

At 1740, or 2 h 20 min past launch, DSS 51 verified that the spacecraft was out of the earth's window.

At 1802 GMT, which was $L + 2$ h 42 min, Station 42 reduced power by 9 dB and reset the power at that time to 1.2 kW.

It was observed for some time that there was a discrepancy in reported AGC signal level from Stations 51 and 42. Station 51 was approximately 14 dB lower in level than DSS 42. Because the DSS 51 antenna was operating against the stops, no particular significance was given to this fact. However, quite some time after autotrack was resumed the problem was still there. Station 51 was requested to go to *aided track*. Within a few minutes the AGC from Station 51 went to a figure which agreed with that from DSS 42.

At 1930 GMT, a very smooth transfer was made from DSS 42 to DSS 51 with everything working normally at 4 h 10 min after launch.

Signal strength reported from DSS 42 at 1930 was $-114.5$ dBmW on receiver 1. At 1942, Station 51 reduced RF power to approximately 1.25 kW. At about 2050, Station 51 was instructed to reduce radiated power until the spacecraft indicated 122.5 dBmW. At 2057, Station 51 reported that it had reduced power to 250 W and still had noticed no significant change in the spacecraft AGC. At this time the spacecraft was reading $-89$ dBmW. At 2102 power was reduced to approximately 100 W with still no significant change. The spacecraft was still reading $-89$. At 2106 it was decided to leave the power at approximately 100 W, as Project hesitated to go much lower.

At 2110 GMT, DSS 42 announced that contact with the spacecraft had been lost, agreeing with predicts.

Figure 55 gives the signal strengths reported by the station plotted on the predicted signal strength curves. The apparent constant difference in signal levels was investigated, with no positive solution obtained.

### B. Deep Space Phase

*1. DSN objectives, phase I.* The main objective of the DSN during phase I of the *Pioneer VII* mission was to acquire the spacecraft S-band signals as early as possible to determine orbit parameters and to acquire continuously telemetry information with the highest S/N ratio and lowest bit error rate possible.

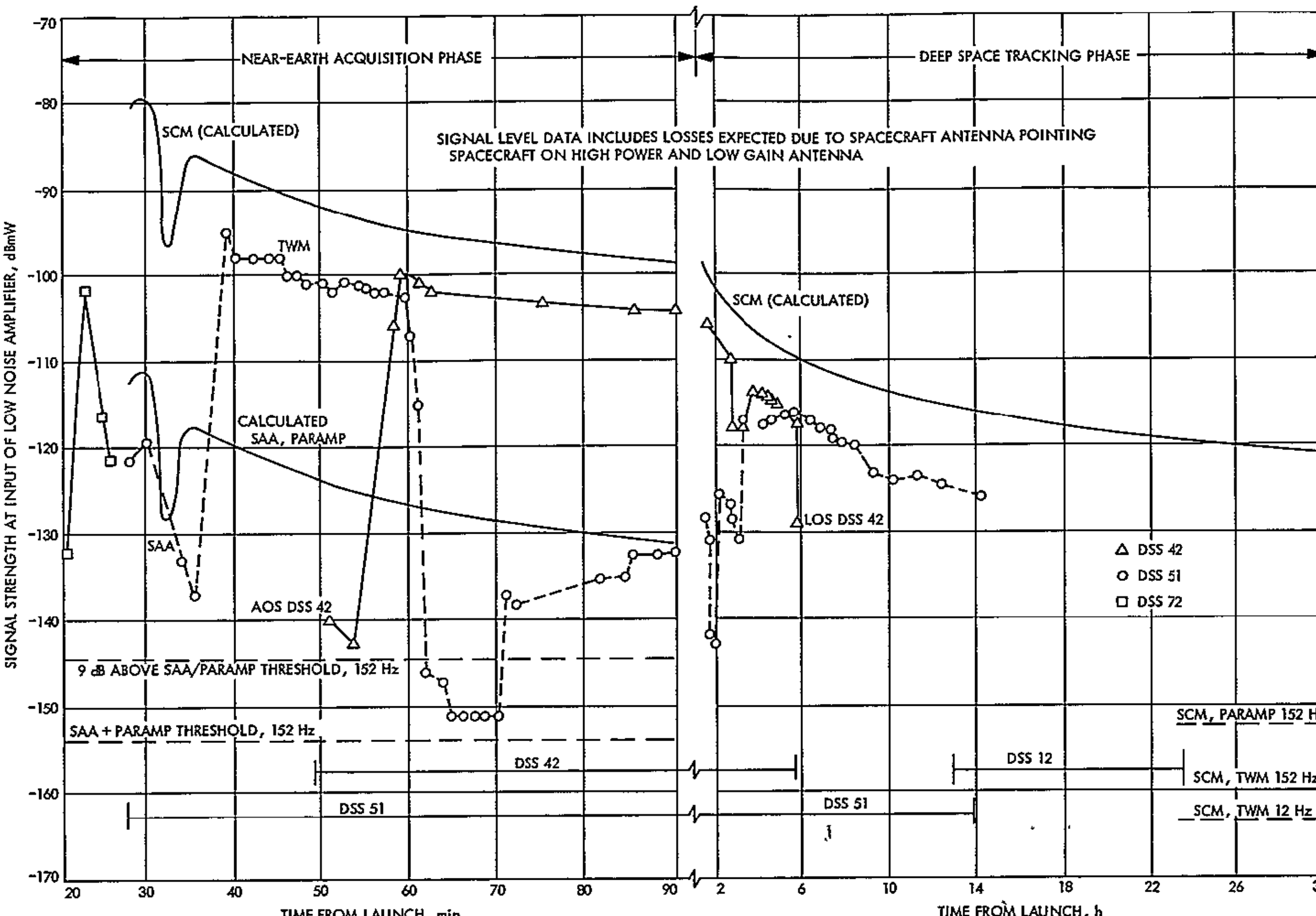


**Fig. 55. Received signal levels for initial acquisition of *Pioneer VII* by the DSN**

Prior to launch, antenna pointing and frequency prediction data based on an assumed nominal launch and parking orbit conditions had been provided to the stations as preliminary acquisition data. After launch, predictions based on (1) AFETR tracking data for first- and second-stage flights, (2) parking orbit, and (3) an assumed nominal third-stage performance had been supplied to the DSN stations in near-real-time to make possible initial acquisition of the *Pioneer VII* spacecraft by DSS 51 and also by DSS 72.

*2. DSN commitments, phase I.* It is the intent of the DSN to furnish all tracking and data acquisition services which are required by the *Pioneer* Project. However, network capabilities and project priorities make it impossible to furnish support which meets all requirements.

Deep Space Stations 12, 42, and 51 have been equipped with the real-time *Pioneer* Project equipment. Emergency backup to track and record the telemetry subcarrier on magnetic tape can be provided by DSS 61, DSS 11, and DSS 41.

The three Deep Space Stations equipped with *Pioneer*-peculiar equipment have been committed as follows: DSS 12—first 30 days, one complete pass per day, day 31 to end of mission, three complete passes per week; DSS 42—first 30 days, one complete pass per day; DSS 51—during the first four days, one complete pass per day for each launch; DSS 71—committed for 30 days preceding each launch for compatibility integration and operations readiness tests as designated in official schedules.

Within the limits of DSN/DSIF loading and station availabilities, every effort will be made to use any or all of the above stations to provide a minimum average coverage of the equivalent of one pass per day from day 31

to the end of the mission. The *Pioneer* spacecraft tracking coverage by the Deep Space Stations equipped with 85-ft antennas will be terminated at a time when the 8-bits/s telemetry data is distorted by a bit error rate of $10^{-3}$ or larger, making further tracking efforts impractical. Cutoff dates will be established by mutual agreements with the *Pioneer* Project Office after the completion of a telemetry error analysis. It was also agreed, that in the event the *Pioneer* Project Office informs DSN management of the possible occurrence of solar flares of class 2 or greater importance, the DSN will exercise every effort to acquire and track the *Pioneer* spacecraft from available stations. The scheduled solar flare tracks will cover at least a total of 30 h. Relative to ground communications commitments, it should be stated that the DSN is scheduled to provide the following subject to circuit priorities: four full-duplex teletype and one voice circuit between the SFOF and Stations 12, 41, and 52. The DSN has also provided three full duplex teletype and three voice circuits between the SFOF and the JPL communications center at Cape Kennedy during launch operations. Furthermore, three full duplex teletype and voice circuits have also been provided between the SFOF and DSS 71 during launch operations.

Based on commitments pertaining to the use of the SFOF, the *Pioneer VII* mission has been provided with the following services and facilities. From the *Pioneer* mission control area, the SFOD directs, during launch operations, all elements of space flight operations, the spacecraft performance analysis and command, and space science analysis and command functions. The FPAC group performs all prelaunch and postlaunch computations necessary for orbit determination and for predictions of the DSN. The DSN is committed to generate medium-accuracy orbits based upon tracking data received from Deep Space Stations. The SFOF is also committed to provide continuous data validation, simulations, and any other services necessary to make a reliable spacecraft acquisition as soon as possible. Precision orbit data is available to meet the required accuracies. The DSN is committed to furnish the *Pioneer VII* mission the best telemetry data possible.

3. *Support provided.* In order to prepare for a successful *Pioneer VII* launch, the following tests and reviews were successfully completed in 1966: FPAC tests on June 16 and 22, SPAC/SSAC acceptance test on June 20, FPAC acceptance tests on June 30, and SFOF integration tests on July 15 and 18. The DSS/AFETR integration tests were made on July 26. Operations readiness test 1 was performed on July 29, and operations readiness test 2 was performed on August 15. After the completion of the DSN tests, DSN and TDS readiness reviews were also made prior to launch.

The *Pioneer VII* launch window, for the first launch date of August 17, 1966, was from 1518 through 1524 GMT. After all tests had proven that all elements of the DSN were ready to support *Pioneer VII* and all necessary and committed stations and facilities reported a green status, the liftoff of *Pioneer VII* occurred on August 17, 1966 at 1520:17 GMT.

4. *DSN support deficiencies and resolution of problems.* The first major constraint imposed upon the DSN by the *Pioneer VII* mission was caused by the decision to move the launch date from the November 1966 window to the August window. Therefore, all major-event schedules and/or milestones previously planned had to be compressed considerably. This constraint affected the NASA/ARC project office just as heavily as it affected the DSN.

The second constraint was caused by the fact that the DSN supported three major launches during a 5-week interval in August and September 1966. In spite of the aforementioned constraints, all elements of the DSN successfully performed most of their assigned tasks in a timely manner, making the *Pioneer VII* mission a success.

5. *DSN commitments and objectives, phase II.* The main objective of the DSN during phase II of the *Pioneer VII* mission was to furnish all tracking and data acquisition services in order to make telemetry information continuously available to the Project with the lowest bit error rate and also to make continuous two-way doppler tracking information available as required to update the orbit parameters and to generate frequency predicts for the Deep Space Stations. The DSN was committed to support the *Pioneer VII* mission for the first four days after launch on a 24-h/day basis in order to make possible a successful type II orientation maneuver; furthermore, the DSN was also committed to make available from Stations 12, (or 11), and 42, respectively, one pass daily from the fifth to the thirtieth day after *Pioneer VII* launch. In addition, the DSN was also committed to provide 100% TDA coverage during the syzygy configuration of *Pioneer VII* three days prior to and at least seven days after the syzygy, which was to occur on day 36 after launch. After completion of the

syzygy tracks, the DSN was further committed to provide from Station 12 at least three complete passes weekly.

Because of the scientific value of the data collected by the *Pioneer VII* spacecraft, every effort will be exercised to make more than three passes per week available. The goal will be at least one pass daily. If Stations 12 and 42 (and perhaps 51), which are equipped with *Pioneer* GOE equipment, are manned, available, and not utilized by other projects, *Pioneer VII* tracks will be scheduled at these stations above the minimum commitment. Stations 11, 41, and 61 can be also utilized for *Pioneer VII* tracks operating on a recording mode.

During solar flare activities of high importance, and acting on instructions received from the *Pioneer* Project, DSN management will request a 30-h TDA coverage on a quick-response basis from the DSIF.

Using the criterion of not more than 1 error in 100 bits, the 85-ft antenna stations will support *Pioneer VII* as follows. The 512-bits/s telemetry bit rate will reach a threshold around November 15, 1966, the 256-bits/s rate on December 8, 1966, the 64 bits/s rate on February 6, 1967, and the 8-bits/s rate on June 13, 1967. The acceptable threshold level will be determined by the *Pioneer* Project; the cutoff date of the 85-ft antenna stations will be established by mutual agreement with the Project Office upon completion of a telemetry error analysis. It is expected that *Pioneer VII* Project management will request utilization of DSS 14 with its 210-ft antenna when the 85-ft antenna stations are not able to deliver usable telemetry data. Figure 56 depicts the *Pioneer VII* signal strength for the first 44 days after launch.

*6. Support provided.* The DSN provided all services necessary to fulfill the above described commitments. During the first four days after launch, Stations 51, 42, and 11 gave 100% 24-h coverage for *Pioneer VII*. Station 11 performed a type II orientation maneuver during pass 2. This maneuver was done by rotating the spacecraft about the sun–probe line and stopping it at that orientation which resulted in the greatest signal strength at earth. At this position, the spin axis is known to be normal to the plane of the earth, sun, and probe. During this maneuver, the spacecraft antenna radiation pattern was plotted successfully and the spacecraft spin axis was positioned to receive the greatest signal strength at the tracking stations around the earth. From day 5

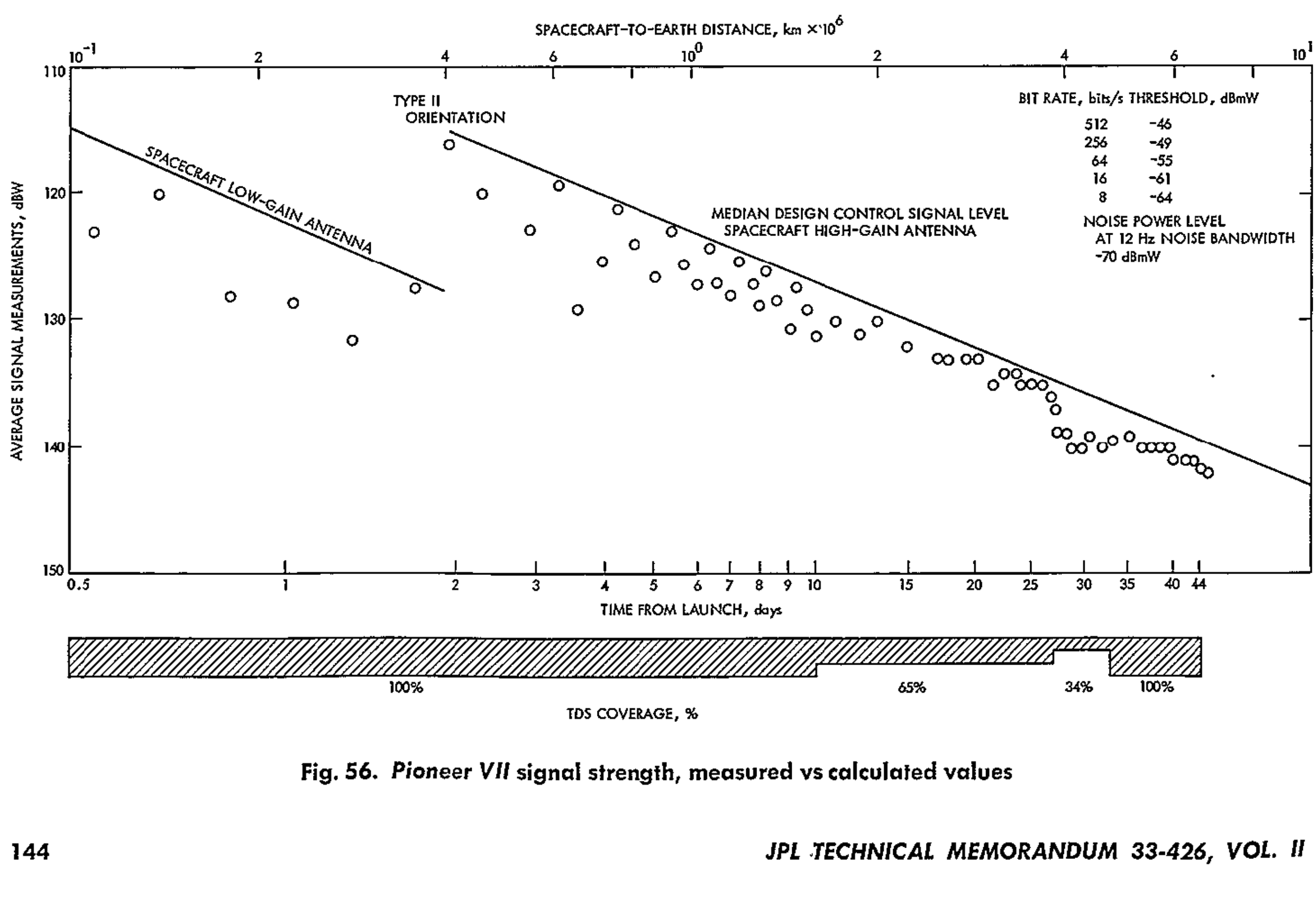


**Fig. 56. *Pioneer VII* signal strength, measured vs calculated values**

through day 10 after launch, the DSN provided 100% TDA coverage utilizing Stations 42, 51, and 11.

From day 11 through day 33 after launch, the DSN provided, on the average, two passes per day, thus meeting the commitments. In order to detect sun radiation anomalies as *Pioneer VII* flew through the tail of the earth, starting day 34 for a time period of 13 days, 100% tracking coverage was provided utilizing Stations 12, 41, and 61. On October 1, the syzygy coverage of *Pioneer VII* was completed, and at the present time the DSN is planning to provide an average of one pass per day, or better, from the available stations.

In summary, the DSN met all requirements and commitments of the *Pioneer VII* mission. Its operation has been flawless and highly successful.

The *Pioneer* Project took numerous risks which were caused by two major constraints: (1) the rescheduling of the launch date, and (2) the fact that the launch window was close to the launch operations of the *Lunar Orbiter* and *Surveyor* Projects.

Because of the peak loading of the DSN, many elements operated without backup hardware; nevertheless, they displayed an excellent operational performance. The systematic training and high team spirit of the members of the network, the results of the preventative maintenance programs, and the application of time-proven software and procedures all contributed to the reliable performance of the rendered support.

***7. Deep Space Instrumentation Facility.*** Cape Kennedy, DSS 71, tracked the carrier and supplied telemetry information until 190 seconds after launch, at which time it lost lock. Ascension Island, DSS 72, locked on the S-band carrier of *Pioneer VII* at 1540:15 GMT, 30 s after station rise, and tracked for over 7 min, at which time the spacecraft reached horizon. The first lock at Station 51, South Africa, was established at $L + 2820$ s, approximately 90 s after the 10-deg rise. Johannesburg, DSS 51, was in autotrack at 1549:40 GMT, which was approximately 2940 s after launch. The signal strength was $-133$ dBmW, and the S-band acquisition aid was utilized. Two-way lock was established at $L + 3710$ s at the same station. At 1602 GMT, DSS 51 went to the S-band Cassegrain monopulse feed operation without reducing the spacecraft static phase error to zero. Therefore, two-way lock was lost. At 1610:52 GMT, the station reestablished to two-way lock and the signal strength at this time was approximately 1100 dBmW. At 1621 GMT, the signal at DSS 51 dropped rapidly to $-115$ dBmW. Therefore, tracking had been transferred to DSS 42 at 1625:30 GMT. The station transfer was earlier than anticipated. Johannesburg, DSS 51, lost lock due to the prelimits of the antenna. Apparently there was a hot third-stage burn and low trajectory causing the spacecraft to dip over the horizon sooner and farther than anticipated. Tidbinbilla, DSS 42, locked up in a two-way mode at 1627 GMT. At 1632 there was a momentary loss of lock on the downlink. The lock was again reestablished in 30 s. At $L + 101$ min, tracking was transferred back from DSS 42 to DSS 51. At $L + 113$ min, DSS 51 was coming back into its antenna limits. Johannesburg, DSS 51, was again on track at 1727 or $L + 127$ min. In the meantime, the spacecraft went through the earth's shadow, and at 1740, $L + 140$ min, it was verified that the spacecraft was not out of the earth's shadow. At 1930 GMT a very smooth transfer was made between DSS 42 and DSS 51. This transfer was made 4 hours and 10 minutes after launch.

***8. DSIF problem areas.*** Approximately 1½ h prior to launch, the DSIF reported a breakdown in the DSS 51 S-band transmitter at full power output. Since for the first acquisition of *Pioneer VII* only a lower power level was required, DSN management requested that the power output of the DSS 51 transmitter be cut down to below 3 kW, at which level no breakdown was detected. This action resulted in a flawless transmitter operation during launch and also during the first pass of DSS 51.

The *Pioneer VII* S-band transmitter had been acquired by Station 72 on an engineering basis and later by Station 51 as scheduled. After Station 51 planned to switch over from the acquisition aid to the Cassegrain monopulse feed, the spacecraft signal was locked on a side lobe of the 85-ft antenna. This deficiency was immediately detected and the spacecraft carrier frequency reacquired on the main lobe of the antenna. This deficiency was caused by the fact that, because of the two major constraints described, there was not enough predicted information available on the 3-sigma deviation of the booster performance and trajectory. Also, because of a lack of available computer time, only a few nominal trajectories and predicts were generated. The rest of the initial tracking operation of *Pioneer VII* was very satisfactory. The early switchover from DSS 51 to DSS 42 was also caused by the somewhat lower trajectory. Figure 57 shows the Johannesburg station (DSS 51) with its 85-ft antenna.

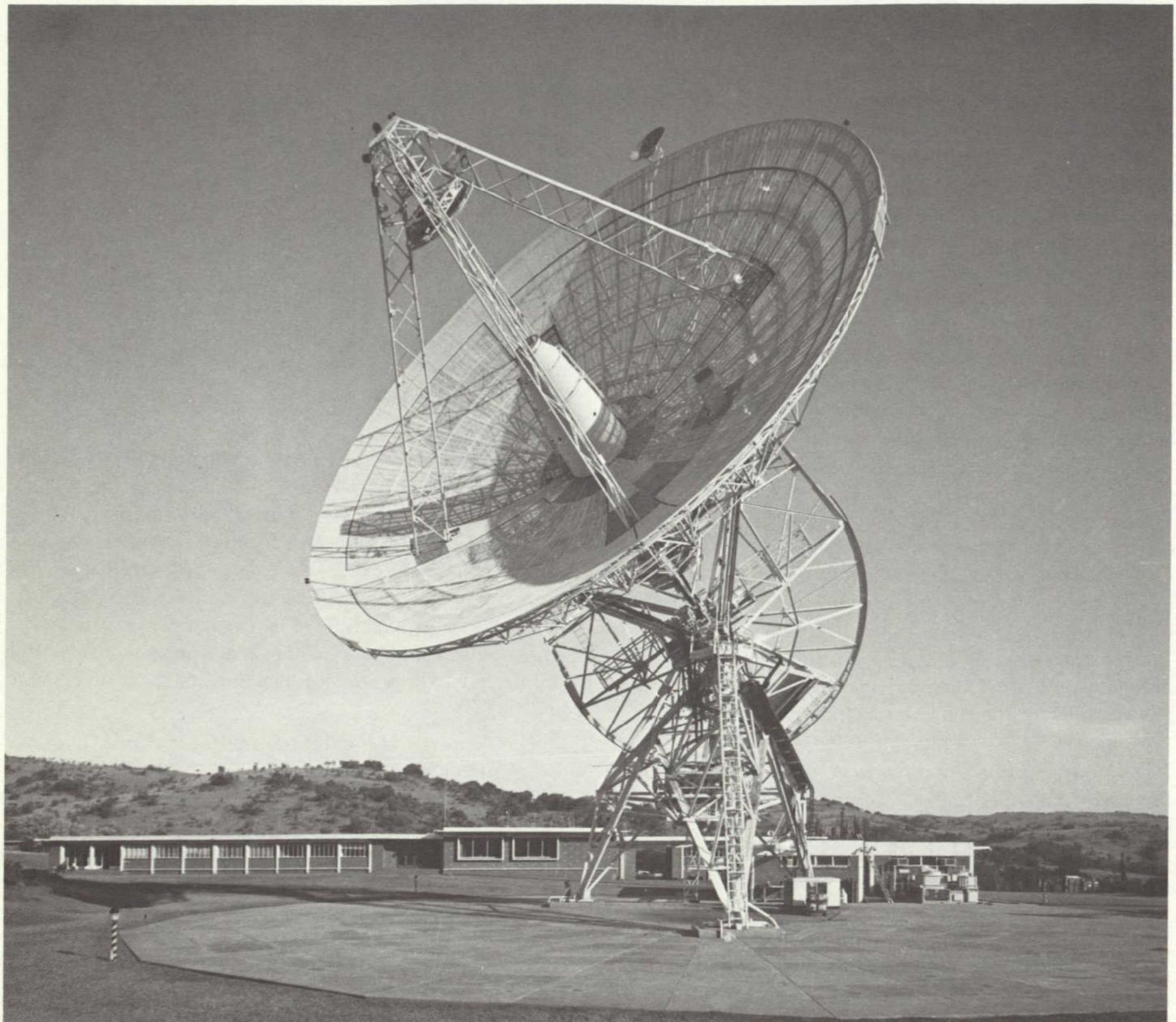

Fig. 57. Johannesburg Deep Space Station (DSS 51) with 85-ft antenna

*9. Phase II support deficiencies and resolution of problems.* During the syzygy full-time tracking coverage, two short gaps in support developed.

(1) The 1-h coverage dropout was accounted for by the fact that DSS 12 was used during the midcourse maneuver of *Surveyor II* as a backup command station to DSS 11. Because of the malfunction of one of the vernier engines of *Surveyor II*, the midcourse maneuver lasted longer than planned, and the station could not be returned in time to track *Pioneer VII*. The second gap in syzygy coverage was recorded during an emergency maneuver of *Surveyor II*. This maneuver was first performed from DSS 51; but after the station lost all communication links with the SFOF, the *Surveyor* Project requested that the *Pioneer* Project relinquish Station 61 for approximately 2 h. Because of the emergency, this was granted by the *Pioneer* Project Office. Telemetry data was lost for about 2 h.

(2) During the third week after launch, Station 51 detected a maser deficiency caused by a loose component. The maser was taken down and completely overhauled. During this time, Station 51 utilized a parametric low-noise amplifier. Fortunately, the prevailing excellent signal-to-noise ratio in the network had not caused any degradation in the bit error rate of telemetry data. Station 12 had a scheduled 10-day maser maintenance operation. Two *Pioneer VII* passes were tracked with the parametric amplifier. No degradation in bit error rate was detected. The SFOF and the GCF have not reported any major support deficiencies. All services have been fully acceptable. Four days after launch, some anomalies occurred pertaining to the transfer of predicts from the SFOF to the Deep Space Stations. These problems were immediately resolved and the predicts delivered in time. These difficulties have been caused by the multilaunch constraints.

*10. DSIF operational performance.*

*a. Passes 1 through 14.* This section describes the tracking performance data of Deep Space Stations 11, 42, 51, 71, and 72 for the first 2 weeks of the *Pioneer VII* flight. Analyses and evaluations have been performed on acquisition procedures, orbit, spacecraft temperatures and frequencies, data availability, and data flow problems.

*Temperature and frequency analysis.* *Pioneer VII* was launched on the first day of its launch window and, except for a very short hold at $L + 4$ min, the countdown was perfect. Mark events and parking orbit were nominal, and injection occurred within its 3-sigma time. Launch time was 1520:17.286 GMT. The trajectory was sufficiently off the nominal trajectory so that, for a 28-min period beginning at 1703 GMT, the spacecraft passed through the earth's shadow. This passage caused a drop in spacecraft temperature, but did not create any severe problems. Initial acquisition on SAA was excellent.

At $L + 28$ min, telemetry data indicated that the temperature was rising at the receiver sensors, although a 6-deg drop was expected. A delayed second acquisition on SCM confirmed this, since the rising temperatures caused acquisition to occur below predicts rather than 10 Hz above, as was expected.

Owing to poor initial orbit estimates, convergence was not rapidly obtained. DSS 72 tracked in one-way mode with excellent angles. However, destructive mode doppler prevented the use of the data for orbital calculations. DSS 51 and DSS 42 both had data for the first orbit which, when finally obtained, was quite good.

During the second pass, DSS 11 performed the type II orientation ($L + 33$ h), with very minor effects on the orbit. However, 12 h after the orientation, a new orbit was calculated to generate predicts for a 2-week period. To supply the DSN with satisfactory frequencies for predicts, DSS 51 made measurements of spacecraft channel 7 and channel 6 rest frequencies on day 231 (Tables 27 and 28). Following are the results of the tests.

Channel 7 predicts indicated a frequency of 21.9889500 MHz, and as the bias was $-45.6$ for up-frequency tuning and $-43.2$ for down-frequency tuning, the rest frequency was approximately 21.988905.0 MHz at VCO level.

Channel 6 predicts indicated a frequency of 21.985260 MHz, and as the bias was $+9.3$ for up-frequency tuning and $+7.4$ for down-frequency tuning, the rest frequency was approximately 21.985268 MHz at VCO level.

Injection time was 1545:38.626 GMT on day 229; post type II orientation injection time was 1300:00 GMT on day 231. This maneuver, performed at $L + 13$ h, was to orient the spacecraft normal to the sun line. The Deep Space Stations stayed in essentially continuous two-way lock mode until pass 11, during which DSS 51 did not

**Table 27. Channel 7 frequency determination**

| Time, GMT | Event |
|---|---|
| 2109 | Channel 6 transmitter turned off |
| 2125 | Channel 7 transmitter turned on to 21.9890000 MHz at 100 W |
| 2126:45 | Began tuning transmitter up-frequency |
| 2128:45 | Frequency lock dropped at 21.9890190 MHz. Predicts indicated a frequency of 21.9890645 MHz with a round trip light time |
| 2130:45 | Channel 7 transmitter turned off |
| 2140:00 | Channel 7 transmitter turned on to 21.9890600 MHz at 100 W |
| 2140:30 | Began tuning transmitter down-frequency. |
| 2144:03 | Frequency lock dropped at 21.9890210 MHz. Predicts 32Y indicated a frequency of 21 9890661 MHz |
| 2149 | Channel 7 transmitter turned off |

**Table 28. Channel 6 frequency determination**

| Time, GMT | Event |
|---|---|
| 2200.00 | Channel 6 transmitter turned on to 21.9853500 MHz at 100 W |
| 2200:10 | Began tuning transmitter up-frequency |
| 2203:26 | Frequency lock dropped at 21.9853873 MHz Predicts indicated a frequency of 21.9853780 MHz |
| 2207:40 | Channel 6 transmitter turned off |
| 2215:00 | Channel 6 transmitter turned on to 21.9854000 MHz at 100 W |
| 2217:02 | Began tuning transmitter down-frequency |
| 2217:54 | Frequency lock dropped at 21.9853870 MHz. Predicts indicated a frequency of 21.9853796 MHz |
| 2218 | Returned to track syn freq and normal tracking |

track. Between passes 11 and 15, several additional rest frequency estimates were made. Channel 7 remained unchanged, but Channel 6 dropped approximately 8 Hz to 21.9852600 MHz at VCO level.

Table 29 is a summary of preflight nominal expected temperature and frequency changes for different launch temperatures. At launch temperature, the rest frequency sensitivity was given as −2.32 Hz/°F on Channel 6 and −5.30 Hz/°F on Channel 7.

Tables 30, 31, and 32 give the tracking data log for Stations 51, 42, and 11, respectively.

*b. Passes 15 through 30.* This section contains tracking performance data for Stations 11, 12, 41, 42, and 51 during the second two weeks of the *Pioneer VII* Mission. Analyses and evaluations have been performed on spacecraft and Deep Space Station performance, trajectory, frequencies and data collection techniques.

*Telemetry.* Table 33 contains telemetry bit rate change data.

**Table 29. Predicted temperature and frequency changes**

| Flight path time, h | Launch temperature | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 72°F | | | 76°F | | | 80°F | | |
| | $\Delta T$ | Δ Frequency, Hz | | $\Delta T$ | Frequency, Hz | | $\Delta T$ | Frequency, Hz | |
| | | Ch 6 | Ch 7 | | Ch 6 | Ch 7 | | Ch 6 | Ch 7 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0 5 | 2.7 | 6.3 | 14.3 | 3.5 | 8.1 | 18.5 | 4.8 | 11.1 | 25.4 |
| 1.0 | 5.0 | 11.6 | 26.5 | 7.1 | 16.5 | 37.6 | 8.7 | 20.2 | 46.0 |
| 1.5 | | | | 6.6 | 22.3 | 50.8 | | | |
| 2.0 | 8.7 | 20.2 | 46.0 | 11.6 | 26.9 | 61.4 | 14.4 | 33.4 | 76.2 |
| 3.0 | | | | 14.4 | 33.4 | 76.2 | | | |
| 4.0 | 11.9 | 27.6 | 63.0 | 15.8 | 36.7 | 83.6 | 19.6 | 45.5 | 103.7 |
| 5.0 | | | | | | | | | |
| 7.0 | 12.5 | 29.0 | 66.2 | 16.5 | 38.3 | 87.3 | 20.5 | 47 6 | 108.5 |
| 9.0 | 12.7 | 29.5 | 67.2 | 16.7 | 38.7 | 88.4 | 20.7 | 48.0 | 109.5 |
| 11.0 | 13.0 | 30.2 | 68.8 | 17.0 | 39.4 | 90 0 | 21.0 | 48.7 | 111.1 |

## Table 30. DSS 51 metric data log (passes 1–10)

| Pass | Day, GMT | Actual time[a] From | Actual time[a] To | WWV clock lag[b], ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 229/230 | 1548:22 | | 47±1 | | | | | |
| | | 1548:34 | 1555:24 | | 8150 | 10/1 | 1555:17 | 1602:17 | |
| | | 1601:24 | 1602:14 | | 8040 | 10/1 | 1603:37 | 1625·01 | |
| | | 1602:34 | 1610·34 | | 8050 | 10/1 | 1930 | 0500.01 | |
| | | | | | 8051 | 10/1 | | | |
| | | 1611:14 | 1612:44 | | 8040 | 10/1 | | | |
| | | 1724:02 | 1929:02 | | 8060 | 60/1 | | | |
| | | 1934:02 | 2152:02 | | 8040 | 60/1 | | | |
| | | 2158:02 | 0458:02 | | 8040 | 60/1 | | | |
| | | 0504:02 | 0547.02 | | 8060 | 60/1 | | | |
| 2 | 230/231 | 1826:11 | | 47±1 | | | 2000:00 | 0515 01 | Computer failed to change day at 000000 |
| | | 1826:37 | 1901:27 | | 8060 | 10/1 | | | |
| | | | | | 8161 | 10/1 | | | |
| | | | | | 8061 | 10/1 | | | |
| | | 1907:13 | 1954:13 | | 8061 | 60/1 | | | |
| | | | | | 8060 | 60/1 | | | |
| | | 2005:13 | 2352:02 | | 8040 | 60/1 | | | |
| | | 2352:37 | 0012.07 | | 8040 | 10/1 | | | |
| | | 0013.02 | 0511:53 | | 8040 | 60/1 | | | |
| | | 0524·38 | 0559:28 | | 8060 | 10/1 | | | |
| 3 | 231/232 | 1835.07 | | 47±1 | | | 1845 | 2109 | 1½ h test to determine channel 6 and channel 7 rest frequencies |
| | | 1856.02 | 2103:02 | | 8040 | 60/1 | 2125 | 2130 | |
| | | 2322:02 | 0306 02 | | 8040 | 60/1 | 2140 | 2149 | |
| | | 0312:02 | 0434:02 | | 8040 | 60/1 | 2200 | 2207 | |
| | | | 0447:00 | | | | 2215 | 0238 | |
| | | | | | | | 0239 | 0445 | |
| 4 | 232/233 | 1930 00 | 0500 | 47±1 | | | 1945 | 0445:01 | Maser warmed up. Reconfigured to paramp |
| 5 | 233/234 | 1832:19 | | 47±1 | | | 1855 | 0455 | |
| | | 1834·02 | 1844.02 | | 8160 | 60/1 | | | |
| | | | | | 8060 | | | | |
| | | 1900:02 | 0454:02 | | 8040 | 60/1 | | | |
| | | | 0518·00 | | | | | | |
| 6 | 234/235 | 1940:12 | | 47±1 | | | | | Degree digit jumping; command buffer operated in abnormal mode. |
| | | 2000.02 | 0454:02 | | 8040 | 60/1 | 1955.00 | 0455:01 | Track performed on paramp due to doubtful maser performance. |
| | | | 0505.00 | | | | | | |
| 7 | 235/236 | 2000:58 | | 47±1 | | | 2015 | 0455:01 | Track performed on paramp. TDH punch 2 inoperative |
| | | 2018:02 | 0444:02 | | 8040 | 60/1 | | | |
| | | 0456:02 | 0516:02 | | 8060 | 60/1 | | | |
| | | | 0518:00 | | | | | | |
| 8 | 236/237 | 1929:57 | | 47±1 | | | 1945 | 0451:00 | Recorder A overheated |
| | | 1949:02 | 0451·02 | | 8040 | 60/1 | | | |
| | | 0453·02 | 0504:02 | | 8050 | 60/1 | | | |
| | | | 0504·44 | | | | | | |

[a] Acquisition time, data sample time periods, and end-of-track time.
[b] Difference between station clock and U.S. Bureau of Standards clock (WWV)
[c] Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.
[d] Time (in s) between doppler counter samplings and the counter multiplier.

**Table 30 (contd)**

| Pass | Day, GMT | Actual time[a] | | WWV clock lag[b], ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | |
| 9 | 237/238 | 1929:30 | | 47±1 | | | | | |
| | | 1950:02 | 0434:02 | | 8040 | 60/1 | 1945.00 | 0445:01 | |
| | | | 0453:00 | | | | | | |
| 10 | 238/239 | 1930:46 | | 47±1 | | | 1945 | 2031 | TXR tripped at 2031; cause being investigated. Switched on at 2035. TXR switched off 5 min early due to operator error |
| | | 1949:02 | 2031:02 | | 8040 | 60/1 | 2035 | 0450 | |
| | | 2039:02 | 0446:02 | | 8040 | 60/1 | | | |
| | | 0501:02 | 0512:02 | | 8060 | 60/1 | | | |

**Table 31. DSS 42 metric data log (passes 1–13)**

| Pass | Day | Actual time[a] | | WWV clock lag,[b] ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | |
| 1 | 229 | 1610:53 | | 30±1 | | | 1625:00 | 1930:01 | |
| | | 1644:12 | 1703:02 | | 8040 | 10/2 | | | |
| | | 1704:02 | 1853:02 | | 8040 | 60/2 | | | |
| | | 1903:02 | 1920:02 | | 8040 | 60/2 | | | |
| | | 1934:02 | 2109:02 | | 8060 | 60/2 | | | |
| | | | 2112:00 | | | | | | |
| 2 | 230 | 1023:11 | | 30±1 | | | 1300 | 1400.00 | |
| | | 1035:02 | 1257:02 | | 8060 | 60/2 | 1403 | 1800:00 | |
| | | 1305:02 | 1400.02 | | 8040 | 60/2 | 1805 | 2000:00 | |
| | | 1425:02 | 1452:02 | | 8040 | 60/2 | | | |
| | | 1457 | 1759:02 | | 8040 | 60/2 | | | |
| | | 1820:02 | 1955:02 | | 8040 | 60/2 | | | |
| | | 2006:02 | 2139:02 | | 8060 | 60/2 | | | |
| 3 | 231 | 1042 | | 30.5 | | | | | Transfer unsatisfactory due to incomplete XA change at TXR turnoff (1845) |
| | | 1122:12 | 1125:52 | | 8060 | 10/2 | | | |
| | | 1136:02 | 1257:02 | | 8060 | 60/2 | | | |
| | | 1304:02 | 1549:02 | | 8040 | 60/2 | | | |
| | | 1549:56 | 1609:54 | | 8040 | 10/2 | | | |
| | | 1611:02 | 1843:31 | | 8040 | 60/2 | | | |
| | | 1857:31 | 1920:31 | | 8060 | 60/2 | | | |
| 4 | 232 | 1239:05 | | 30±1 | | | 1305 | 1945:01 | Transfer from 11 delayed 5 min, due to hung relay. CEC traces lost 1853 to 1917; lamp replaced |
| | | 1244:12 | 1307:12 | | 8060 | 10/2 | | | |
| | | 1307:22 | 1311:22 | | 8040 | 10/2 | | | |
| | | 1314:02 | 1553:02 | | 8040 | 60/2 | | | |
| | | 1555:11 | 1610.01 | | 8040 | 10/2 | | | |
| | 232 | | | 30±1 | | | | | |
| | | 1611:02 | 1944:02 | | 8040 | 60/2 | | | |
| | | 1950:02 | 1959:02 | | 8060 | 60/2 | | | |
| | | | 2030 | | | | | | |

[a]Acquisition time, data sample time periods, and end-of-track time.
[b]Difference between station clock and U.S Bureau of Standards clock (WWV)
[c]Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.
[d]Time (in s) between doppler counter samplings and the counter multiplier.

Table 31 (contd)

| Pass | Day | Actual time[a] | | WWV clock lag,[b] ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | |
| 5 | 233 | 1255 | | 30±1 | | | 1310 | 1855 | |
| | | 1314:02 | 1844:02 | | 8040 | 60/2 | | | |
| | | | 1940 | | | | | | |
| 6 | 234 | | | 30.5±1 | | | 1300 | 1955 | |
| | | 1305:02 | 1945:02 | | 8040 | 60/2 | | | |
| | | 2000:02 | 2040:02 | | 8060 | 60/2 | | | |
| 7 | 235 | | | 30.5±1 | | | 1305 | 2015 | |
| | | 1245:02 | 1259:02 | | 8060 | 60/2 | | | |
| | | 1309:02 | 2005:02 | | 8040 | 60/2 | | | |
| | | | 2027 | | | | | | |
| 8 | 236 | 1228:37 | | 30±1 | | | 1300.01 | 1945.01 | Doppler recycled; operator error. Data garbled |
| | | 1232:02 | 1255:02 | | 8060 | 60/2 | | | |
| | | 1304:02 | 1325:02 | | 8040 | 60/2 | | | |
| | | 1330:02 | 1935:02 | | 8040 | 60/2 | | | |
| | | 1950.02 | 2030:02 | | 8060 | 60/2 | | | |
| 9 | 237 | 1237 | | 30±1 | | | 1430 | 1945 | 1255, DIS printing +4 h on engineering science; cleared at 1407. 1837Z, synthesizer counter adjusted; last 4 digits, 5381, should be 5380 |
| | | 1447:02 | 1933.02 | | 8040 | 60/2 | | | |
| | | | 1955 | | | | | | |
| 10 | 238 | 1245 | | 30.5±1 | | | 1300 | 1945 | |
| | | 1304.02 | 1933.02 | | 8040 | 60/2 | | | |
| | | 1951:02 | 2016:02 | | 8060 | 60/2 | | | |
| | | | 2017 | | | | | | |
| 11 | 239 | 1232:54 | | 195±2 | | | 1305 | 2027 | 1340; maser power supply failed Switched to paramp. Returned to maser at 1830. GOE 300-V power supply failed at 1940. Last 10 min of playback normal |
| | | 1236.02 | 1300.02 | | 8060 | 60/2 | | | |
| | | 1311:02 | 2026.02 | | 8040 | 60/2 | | | |
| | | | 2027 | | | | | | |
| 12 | 240 | 1229 | | 30±1 | | | 1300 | 2100 | 1055 GOE computer buffer causing spurious interrupt to computer. 1345 computer B failed due to memory parity errors. Last 10 min playback normal |
| | | 1232 | 1249 | | 8060 | 60/2 | | | |
| | | 1304 | 2100 | | 8040 | 60/2 | | | |
| | | | 2100 | | | | | | |
| 13 | 241 | 1230 | | 30±1 | | | 1245 | 2108 | |
| | | 1249:02 | 2107:02 | | 8040 | 60/2 | | | |
| | | | 2108 | | | | | | |

## Table 32. DSS 11 metric data log (passes 1–13)

| Pass | Day | Actual time[a] | | WWV clock lag,[b] ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | |
| 1 | 230 | 0425:20 | | 12±1 | | | 0500:00 | 1300:01 | |
| | | 0440:02 | 0457:02 | | 8060 | 60/2 | | | |
| | | 0503:02 | 0749:02 | | 8040 | 60/2 | | | |
| | | 0756.02 | 1256:02 | | 8040 | 60/2 | | | |
| | | 1305.02 | 1400.02 | | 8060 | 60/2 | | | |
| | | 1405:02 | 1427.02 | | 8150 | 60/2 | | | |
| | | 1428:02 | 1513:02 | | 8160 | 60/2 | | | |
| | | | | | 8060 | 60/2 | | | |
| | | | 1514:10 | | | | | | |
| 2 | 231 | 0429:43 | 1537:15 | 12±1 | | | 0515 | 0905 | TXR tripped off at 0905 due to body flow overcurrent. HSD tape broke; lost 30 min of data |
| | | | | | | | 0906 | 1300 | |
| 3 | 232 | 0425:32 | 1310·00 | 12±1 | | | 0445 | 1232 | TXR tripped off due to body flow overcurrent |
| | | 0426:20 | 0435 | | 8060 | 10/2 | 1236 | 1305 | |
| | | 0448:10 | 0514:00 | | 8040 | 10/2 | | | |
| | | 0516:02 | 0933·02 | | 8040 | 60/2 | | | |
| | | 0934:13 | 0953:53 | | 8040 | 10/2 | | | |
| | | 0956:02 | 1259:50 | | 8040 | 60/2 | | | |
| | | | 1310.00 | | | | | | |
| 4 | 233 | 0422·56 | | 12±1 | | | 0445 | 1310 | Commercial power surge at 1030 went to diesel power. Dec angle readout biased by 10 deg |
| | | 0451:02 | 1310.02 | | 8040 | 60/2 | | | |
| | | 1314:02 | 1345:02 | | 8060 | 60/2 | | | |
| 5 | 234 | 0419:40 | | 12±1 | | | 0455 | 1300 | |
| | | 0423·02 | 0449:02 | | 8060 | 60/2 | | | |
| | | 0511:02 | 1249:02 | | 8040 | 60/2 | | | |
| | | 1305.02 | 1324:02 | | 8060 | 60/2 | | | |
| 6 | 235 | 0416:20 | | 12±1 | | | 0455 | 1305:01 | TDH TTY printing garbled. TDH dec angle readout error at 0500 |
| | | 0423:02 | 0444:02 | | 8060 | 60/2 | | | |
| | | 0500:02 | 1259:02 | | 8040 | 60/2 | | | |
| | | 1310:02 | 1324·02 | | 8060 | 60/2 | | | |
| 7 | 236 | 0412:38 | | 12±1 | | | 0455·00 | 1300:00 | TDH hour angle printout error. Oscillation in datex dec. readout at acquisition |
| | | 0415:06 | 0444 02 | | 8160 | 60/2 | | | |
| | | | | | 8060 | 60/2 | | | |
| | | 0500.02 | 1255.02 | | 8040 | 60/2 | | | |
| | | 1305:02 | 1216·02 | | 8060 | 60/2 | | | |
| 8 | 237 | 0415.00 | | 12±1 | | | 0500 | 1425:18 | Parity errors from 0505 to 0532. Cause unknown. TDH punch 1 garbled. TXR tripped out due to RF power output interlock; unable to achieve sufficient power to maintain S/C signal strength −122 dBmw |
| | | 0417:02 | 0451:02 | | 8160 | 60/2 | | | |
| | | | | | 8060 | 60/2 | | | |
| | | 0453 02 | 0457·02 | | 8150 | 60/2 | | | |
| | | 0528:02 | 1425.02 | | 8040 | 60/2 | | | |

[a]Acquisition time, data sample time periods, and end-of-track time.

[b]Difference between station clock and U S Bureau of Standards clock (WWV)

[c]Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.

[d]Time (in s) between doppler counter samplings and the counter multiplier.

## Table 32 (contd)

| Pass | Day | Actual time[a] | | WWV clock lag,[b] ms | Data code[c] | Sample rate and multiplier[d] | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | |
| 9 | 238 | 0418:37 | | 12±1 | | | | 1300 | TDH punch 1 failed due to bad tape guide. Switched to No. 2 punch: Operation normal. Punch 2 failed due to bad TD. Switched back to punch 1, which had been repaired. Unable to play back tapes due to PN-06 track. Telemetry not recorded on FR-1400 Recorder B from 0749 to 0900 due to recorder problem |
| | | 0451:02 | 1254:02 | | 8040 | 60/2 | | | |
| | | 1305:02 | 1316.02 | | 8060 | 60/2 | | | |
| 10 | 239 | 0402:40 | | 12±1 | | | 0455 | 1308 | Due to TDH brake arm misalignment, no tracking data was sent from 0511:02 to 0545.02 and from 0648:00 to 0703:02 SDS 920 computer was programmed to monitor TDH equipment and data was sent at end of track. CEC recorder-individual channel amplifiers not turned on; data was not recorded |
| | | 0404:02 | 0446:02 | | 8160 | 60/2 | | | |
| | | | | | 8060 | 60/2 | | | |
| | | 0506.02 | 1259:02 | | 8040 | 60/2 | | | |
| | | | 1310:00 | | | | | | |
| 11 | 240 | 0416 | | 12±1 | | | | | |
| | | 0455:02 | 1249:02 | | 8140 | 60/2 | 0425.00 | 1300 | |
| | | | | | 8040 | 60/2 | | | |
| | | 1306:02 | 1316:02 | | 8060 | 60/2 | | | |
| 12 | 241 | 0505:56 | | 12±1 | | | 0507:38 | 1245:01 | Telemetry was poor until 0645 when bit rate was changed from 512 to 256 bits/s. Command mod switch off for command at 0515, DSS 11 control error. DSS 11/12 bit error test indicated excessive bit error rate due to bit error tester malfunction |
| | | 0515:02 | 1234:02 | | 8140 | 60/2 | | | |
| | | | | | 8040 | 60/2 | | | |
| | | | 1255:00 | | | | | | |
| 13 | 242 | 0354:37 | | 12±1 | | | N/R | N/R | DSS 11/12 CEC recorder excitation lamp failed. Voice line to SFOF was out for 15 min |
| | | 0404:59 | 0431:49 | | 8040 | 10/2 | | | |
| | | 0433:02 | 0902:02 | | 8040 | 60/2 | | | |
| | | 0903-58 | 0923:38 | | 8040 | 10/2 | | | |
| | | 0925:02 | 1440:02 | | 8040 | 60/2 | | | |
| | | 1441:05 | 1454:35 | | 8040 | 10/2 | | | |
| | | 1456:15 | 1504:55 | | 8050 | 10/2 | | | |

Table 33. Predicted vs actual telemetry bit rate changes for 85-ft antennas (December 1966–March 1967)

| Predicted[a] | | | | | Actual | | |
|---|---|---|---|---|---|---|---|
| Time from launch, days (desired) | Time from launch, days (forecast) | Desired range, km × $10^6$ | Forecast range, km × $10^6$ | Expected bit rate, bits/s | Time from launch, days | Range, km × $10^6$ | Bit rate, bits/s |
| 69 | | 9.1255 | | 512 | 67 (10/24/66) | 11.7790 | 512 |
| 84 | | 13.463865 | | 256 | 80 (11/6/66) | 15.7888 | 256 |
| 114 | 112 (12/8/66) | 27.07733 | 28.72189 | 64 | | | |
| 130 | 135 (12/31/66) | 39.04520 | 40.011637 | 16 | | | |
| 178 | 204 (3/11/67) | 76.2952 | 76.00 | 8 | | | |

[a]Based on expected values for *Pioneer VII* spacecraft tracked mode in coherent mode with a parity error rate of 0.10%.

*Trajectory data.* Figures 58, 59, and 60 present *Pioneer VII* predicted range, radial velocity, and round trip light time. Predicted performance has been included up to pass 200 and is based on the latest orbit determination data.

*Tracking data logs.* Tables 34–37 contain tracking performance data for Stations 51, 42, 11, and 12, which tracked during passes 15 through 30.

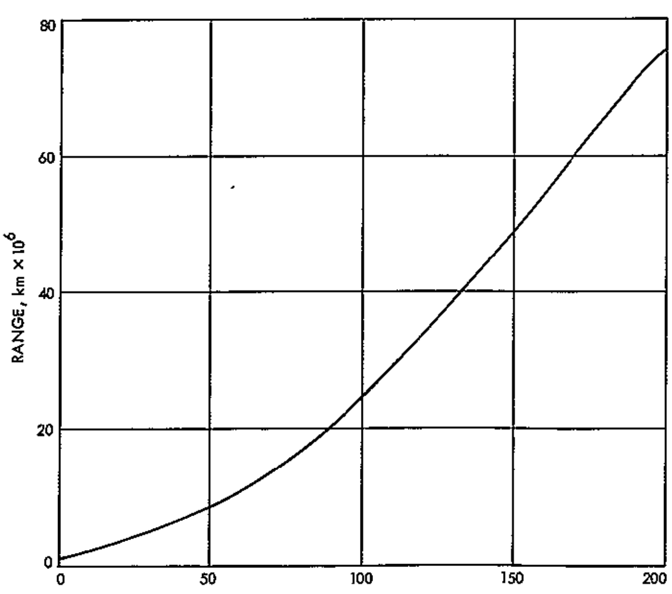


**Fig. 58. *Pioneer VII* range**

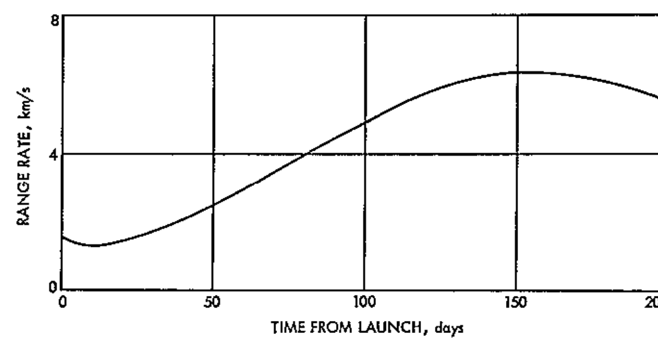


**Fig. 59. *Pioneer VII* radial velocity**

*Data collection.* Automation of data collection and analysis is continuing during this reporting period. The latest achievement is a program which processes acquisition frequencies and computes spacecraft rest frequency estimates. Results are used to generate predicts and perform statistical analyses on acquisition performance. Tables 34–37 contain some of the output from this program.

*Spacecraft performance.* A gas leak was discovered in the *Pioneer VII* orientation system. It may be recalled that *Pioneer VI* experienced a similar leak of relatively high magnitude, resulting in a 90% pressure loss during the first six months of the *Pioneer VI* mission. The *Pioneer VII* pressure leak appears to be much smaller, and, though noticeable in the data, will take much longer to determine accurately. However, future orbit determinations and the use of a new orbit determination

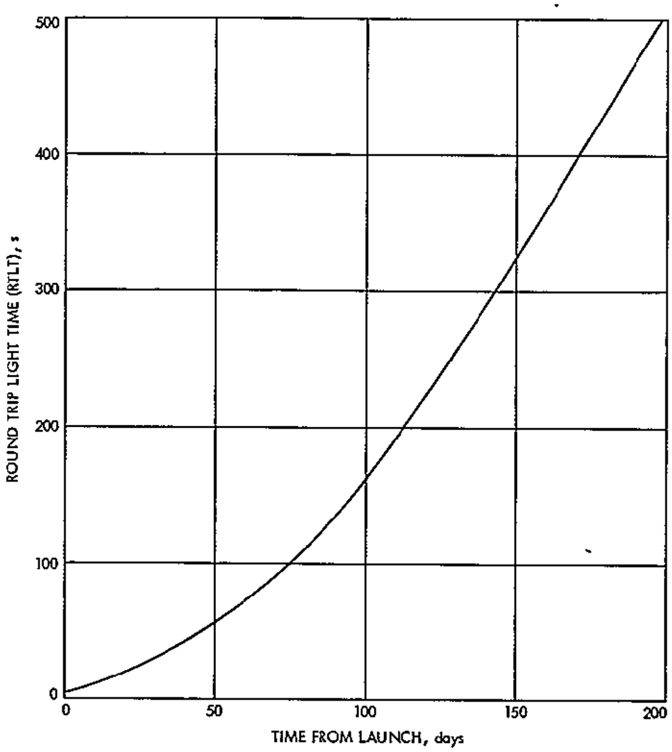


**Fig. 60. *Pioneer VII* round trip light time**

model (developed since *Pioneer VI*) have provided more accurate estimates of the phenomena.

*c. Passes 31 through 45.* This section contains tracking and engineering performance data for Stations 12, 14, 41, 42, 51, and 61 for days 260 through 274 (September 17 through October 1, 1966). The following engineering and tracking performance data is presented:

| Engineering Data | |
|---|---|
| Table 38 | Predicted vs actual *Pioneer VII* telemetry bit rate changes for Deep Space Station 85-ft antennas |
| Fig. 61 | Received signal strength and bit error rate, passes 31 through 45 |
| Fig. 62 | RF/demodulator/TCP performance history |
| Fig. 63 | Spacecraft receiver and transmitter driver temperatures |
| Fig. 64 | Predicted total power level at face of Deep Space Station antenna |
| Fig. 65 | Spacecraft signal level vs tuning rate |
| Fig. 66 | Channel 6 or channel 7 lockup time |
| **Tracking data** | |
| Table 39 | Tracking plans and definitions |
| Fig. 67 | *Pioneer VII* rest frequency (channel 6) |
| Fig. 68 | *Pioneer VII* rest frequency (channel 7) |

**Table 34. DSS 51 tracking data log (passes 15–30)**

| Pass | Day | Actual time[a] | | WWV clock lag,[b] ms | Data code[c] | Sample rate and multiplier[d] | No. points[e] | Good points,[f] % | Transmitter on | Transmitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | | | |
| 15 | 243/244 | 2011:00 | | | | | | | | | Special solar flare pass. Good point %-is based on acquisition time instead of scheduled time |
| 16–21 | 245/246 | 2052.02 | 0352:02<br>0352:54 | | 8040 | 60/1 | 420 | 91.1 | 2045 | 0358:30 | |
| 22, 23[g] | | | | | | | | | | | |
| 24 | 252/253 | 2013 02 | 0352:02 | | 8040 | 60/1 | 433 | 88.2 | 2005 | 0340 | |
| 25–30[h] | | | | | | | | | | | |

[a]Acquisition time, data sample time periods, and end-of-track time.
[b]Difference between station clock and U.S. Bureau of Standards clock (WWV).
[c]Data acquisition mode Digits denote (1) doppler averag'ng time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard
[d]Time (in s) between doppler counter samplings and the counter multiplier.
[e]Number of good data points obtained in interval.
[f]Percentage of good data points obtained per pass.
[g]To be supplied.
[h]No track.

## Table 35. DSS 42 metric data log (passes 15–30)

| Pass | Day | Actual time | | WWV clock lag, ms | Data code | Sample rate and multiplier | No. points | Good points, % | Trans-mitter on | Trans-mitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | | | |
| 15 | 243 | 1238- | | | | | | 89.8 | 1300 | 1730 | |
| | | 1245:42 | 1258:12 | | 8050 | 10/2 | 78 | | 1830 | 2047 | |
| | | 1310:22 | 1325:12 | | 8040 | 10/2 | 90 | | | | |
| | | 1329:02 | 1515.02 | | 8040 | 60/2 | 106 | | | | |
| | | 1516·22 | 1534:42 | | 8040 | 10/2 | 108 | | | | |
| | | 1537:02 | 1728.02 | | 8040 | 60/2 | 111 | | | | |
| | | 1733:02 | 1827.02 | | 8050 | 60/2 | 54 | | | | |
| | | 1846:02 | 2025.02 | | 8040 | 60/2 | 109 | | | | |
| | | 2026:02 | 2047·32 | | 8040 | 10/2 | 132 | | | | |
| | | 2051:32 | 2102:02 | | 8060 | 10/2 | 66 | | | | |
| 16 | 244 | 1011- | | | | | | 91.9 | 1027·50 | 1605 | |
| | | 1033.02 | 1559:02 | | 8040 | 60/2 | 326 | | 1630 | 2048 | |
| | | 1608:02 | 1627.02 | | 8050 | 60/2 | 19 | | | | |
| | | 1641:02 | 2048:02 | | 8040 | 60/2 | 247 | | | | |
| | | | 2050 | | | | | | | | |
| 17 | 245 | 1009:27 | | | | | | | 1015 | 2044 | |
| | | 1042:02 | 2041:62 | | 8040 | 60/2 | 599 | 92.8 | | | |
| 18 | 246 | 1209:53 | | | | | | | 1230 | 2029 | |
| | | 1234:02 | 2028:52 | | 8040 | 60/2 | 474 | 73.6 | | | |
| 19 | 247 | 1209 | | | | | | | 1230 | 2018 | |
| | | 1238:02 | 2018:02 | | 8040 | 60/2 | 460 | 89.3 | | | |
| 20 | 248 | 1225.02 | 2007:02 | | 8040 | 60/2 | 463 | 89.7 | 1220 | 2007 | |
| 21 | 249 | 1146:02 | 1155:02 | | 8060 | 60/2 | 10 | 85.5 | 1200 | 2005 | Bad doppler not re- |
| | | 1207:02 | 1529.02 | | 8040 | 60/2 | 203 | | | | flected in DCC from |
| | | 1605.02 | 2005.02 | | 8040 | 60/2 | 241 | | | | 1530 to 1604 |
| 22 | 250 | 1202:02 | 1210:02 | | 8060 | 60/2 | 9 | 88.6 | 1245 | 2010 | |
| | | 1214·02 | 1230:02 | | 8160 | 60/2 | 17 | | | | |
| | | 1256:02 | 2000:02 | | 8040 | 60/2 | 425 | | | | |
| | | 2020:02 | 2025:02 | | 8060 | 60/2 | 6 | | | | |
| 23 | 251 | 1216 02 | 1953:02 | | 8040 | 60/2 | 458 | 90.3 | 1200 | 2005 | |
| | | 2018:02 | 2025 02 | | 8060 | 60/2 | 8 | | | | |
| 24 | 252 | 1231:02 | 1237:02 | | 8050 | 60/2 | 7 | 90.7 | 1240 | 2005 | |
| | | 1253:02 | 1949:02 | | 8040 | 60/2 | 417 | | | | |
| | | 2017:02 | 2022:02 | | 8060 | 60/2 | 6 | | | | |
| 25 | 253 | 1007.03 | 1018:02 | | 8060 | 60/2 | 12 | 93.7 | 1025 | 1957 | |
| | | 1034.02 | 1957:02 | | 8040 | 60/2 | 564 | | | | |
| 26 | 254 | 1016:02 | 1029:02 | | 8060 | 60/2 | 14 | 91.7 | 1035 | 1946 | |
| | | 1049:02 | 1947:02 | | 8040 | 60/2 | 539 | | | | |
| 27 | 255 | 1024:02 | 1035:02 | | 8060 | 60/2 | 12 | 93.9 | 1045 | 1955 | |
| | | 1054:02 | 1955:02 | | 8040 | 60/2 | 542 | | | | |
| 28–30[g] | | | | | | | | | | | |

[a]Acquisition time, data sample time periods, and end-of-track time.
[b]Difference between station clock and U.S. Bureau of Standards clock (WWV).
[c]Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.
[d]Time (in s) between doppler counter samplings and the counter multiplier.
[e]Number of good data points obtained in interval.
[f]Percentage of good data points obtained per pass
[g]No track.

## Table 36. DSS 11 metric data log (passes 15–30)

| Pass | Day | Actual time | | WWV clock lag, ms | Data code | Sample rate and multiplier | No. points | Good points, % | Trans-mitter on | Trans-mitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | | | |
| 15 | 244 | 0354:40 | | | | | | | | | |
| | | 0415.02 | 1026:02 | | 8040 | 60/2 | 371 | 92.5 | g | g | |
| | | | 1032:00 | | | | | | | | |
| 16[h] | | | | | | | | | | | |
| 17 | 246 | 0336 | | | | | | | | | TDH Punch 1 failed. |
| | | 0353:08 | 1216:01 | | 8040 | 60/2 | 543 | 105.1 | g | g | No data sent from |
| | | 1220.01 | 1229.01 | | 8040 | 60/2 | 9 | | | | 0718:00 to 0756 00 |
| 18 | 247 | 0331:05 | | | | | | | | | |
| | | 0351:02 | 1229:02 | | 8040 | 60/2 | 558 | 98 0 | g | g | |
| | | | 1240:00 | | 8140 | | | | | | |
| 19 | 248 | 0327:02 | | | | | | | | | |
| | | 0355:02 | 1210.02 | | 8040 | 60/2 | 525 | 92.2 | g | g | |
| | | | 1227:00 | | | | | | | | |
| 20 | 249 | 0322:33 | | | | | | | | | |
| | | 0338:02 | 1154:02 | | 8040 | 60/2 | 497 | 93.3 | 0330 | 1200 | |
| | | 1206:02 | 1216:02 | | 8060 | 60/2 | 11 | | | | |
| | | | 1217 | | | | | | | | |
| 21 | 250 | 0320.30 | | | | | | | | | TDH had erroneous |
| | | 0346.02 | 0402:02 | | 8140 | 60/2 | 17 | 96.5 | 0330 | 1245 | printout in HA |
| | | 0432:02 | 1234:02 | | 8040 | 60/2 | 512 | | | | |
| | | 1301:02 | 1306.02 | | 8060 | 60/2 | 6 | | | | |
| 22–30[h] | | | | | | | | | | | |

[a]Acquisition time, data sample time periods, and end-of-track time.
[b]Difference between station clock and U.S. Bureau of Standards clock (WWV).
[c]Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.
[d]Time (in s) between doppler counter samplings and the counter multiplier.
[e]Number of good data points obtained in interval.
[f]Percentage of good data points obtained per pass.
[g]To be supplied.
[h]No track.

Table 37. DSS 12 metric data log (passes 15–30)

| Pass | Day | Actual time | | WWV clock lag, ms | Data code | Sample rate and multiplier | No. points | Good points, % | Trans-mitter on | Trans-mitter off | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | | | | |
| 15–23[g] | | | | | | | | | | | |
| 24 | 253 | 0309:30 | | | | | | | | | |
| | | 0314:02 | 0325:02 | | 8160 | 60/2 | 12 | 87.7 | 0340 | 1025 | |
| | | 0353:02 | 1014:02 | | 8140 | 60/2 | 382 | | | | |
| | | | 1035:00 | | | | | | | | |
| 25 | 254 | 0255 | | | | | | | | | |
| | | 0313.02 | 0319:02 | | 8040 | 60/2 | 7 | 89.4 | 0300 | 1035 | |
| | | 0335:02 | 0830.02 | | 8040 | 60/2 | 296 | | | | |
| | | 0831:02 | 1029:02 | | 8140 | 60/2 | 119 | | | | |
| | | | 1043 | | | | | | | | |
| 26 | 255 | 0255 | | | | | | | | | |
| | | 0316:02 | 0351:02 | | 8040 | 60/2 | 36 | 82.1 | 0300 | 1045 | |
| | | 0409.02 | 1034:02 | | 8040 | 60/2 | 386 | | | | |
| | | | 1052 | | | | | | | | |
| 27 | 256 | 0252 | | | | | | | | | |
| | | 0310·02 | 0315:02 | | 8040 | 60/2 | 6 | 84.1 | 0253 | 1048 | |
| | | 0330:02 | 1048:02 | | 8040 | 60/2 | 439 | | | | |
| 28 | 257 | 0245 | | | | | | | | | |
| | | 0258:02 | 0303:02 | | 8140 | 60/2 | 6 | 88.4 | 0250 | 1350 | |
| | | 0321:02 | 1349.07 | | 8140 | 60/2 | 629 | | | | |
| 29 | 258 | 0245 | | | | | | | | | |
| | | 0314.02 | 1119:02 | | 8140 | 60/2 | 485 | 85.8 | 0252 | 1119 | |
| | | | 1120 | | 8040 | | | | | | |
| | | | | | 8140 | | | | | | |
| 30 | 259 | 0240 | | | | | | | | | |
| | | 0303:02 | 1350:02 | | 8140 | 60/2 | 647 | 95.5 | 0245 | 1350 | |

[a]Acquisition time, data sample time periods, and end-of-track time.
[b]Difference between station clock and U S. Bureau of Standards clock (WWV).
[c]Data acquisition mode. Digits denote (1) doppler averaging time, (2) receiver and servo data condition, (3) doppler mode, and (4) atomic frequency standard.
[d]Time (in s) between doppler counter samplings and the counter multiplier.
[e]Number of good data points obtained in interval.
[f]Percentage of good data points obtained per pass.
[g]No track.

Table 38. **Predicted vs actual telemetry bit rate changes for 85-ft antennas (November–December 1966)**

| Predicted[a] | | | | | Actual | | |
|---|---|---|---|---|---|---|---|
| Time from launch, days, desired | Time from launch, days, forecast | Desired range, km × $10^6$ | Forecast range, km × $10^6$ | Expected bit rate, bits/s | Time from launch, days | Range, km × $10^6$ | Bit rate, bits/s |
| 69 | | 9 1255 | | 512 | 67 (10/24/66) | 11.7790 | 512 |
| 84 | | 13.463865 | | 256 | 80 (11/6/66) | 15.7888 | 256 |
| 114 | 112 (12/8/66) | 27.07733 | 28.72189 | 64[a] | 114 (12/11/66) | 29.5 | 64 |
| 130 | 135 (1/30/67) | 39.04520 | 57.0 | 16 | | | |
| 222 | 204 (4/25/67) | 94.00 | 94.00 | 8 | | | |

[a]Calculation of telemetry margin threshold for 64 bits/s.

(1) Present space loss $(SL)_2 = 37 + 67 + 20 \log \text{range}$
$= 104 + 20 \log (24.6911 \times 10^6 \times 0\ 62)$
$= 104 + 20 \log (153.08484 \times 10^5)$
$= 104 + 20.(5.1847)$
$= 207.5$ dBmW

(2) Forecasted space loss $(SL)_1 = 104 + 20 \log (28.72189 \times 10^6 \times 0.62)$
$= 104 + 20 \log (178\,075 \times 10^5)$
$= 104 + 20\ (5\ 2504)$
$= 209$ dBmW

(3) $SL_1 - SL_2 \cong 2$ dBmW threshold margin for 64 bits/s

(4) Present signal, November 29, 1966 = −155 dBmW.

(5) Predicted threshold for 64 bits/s = −157 dBmW around December 8, 1966.

(6) Actual threshold for 64 bits/s = −156 5 dBmW on December 14, 1966.

Table 39. **Tracking plans and definitions**

| Pass | Station | Plan | Pass | Station | Plan | Pass | Station | Plan | Pass | Station | Plan |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 12 | A | 39 | 12 | A | 36 | 12 | A | 43 | 12 | A |
| 32 | 12 | A | | 42 | A | | 41 | A | | 42 | A |
| 33 | 61 | A | | 51 | A | | 61 | A | | 51 | A |
| 34 | 12 | A | 40 | 12 | A | 37 | 12 | A | 44 | 12 | A |
| | 41 | D | | 42 | A | | 14 | A | | 42 | A |
| | 61 | D | | 51 | A | | 41 | A | | 51 | A |
| 35 | 12 | A | 41 | 12 | D | | 61 | A | 45 | 12 | A |
| | 41 | A | | 42 | D | 38 | 12 | A | | 14 | A |
| | 61 | A | | 51 | D | | 41 | A | | 42 | A |
| | | | 42 | 12 | A | | 61 | A | | 51 | A |
| | | | | 42 | A | | | | | | |
| | | | | 51 | A | | | | | | |

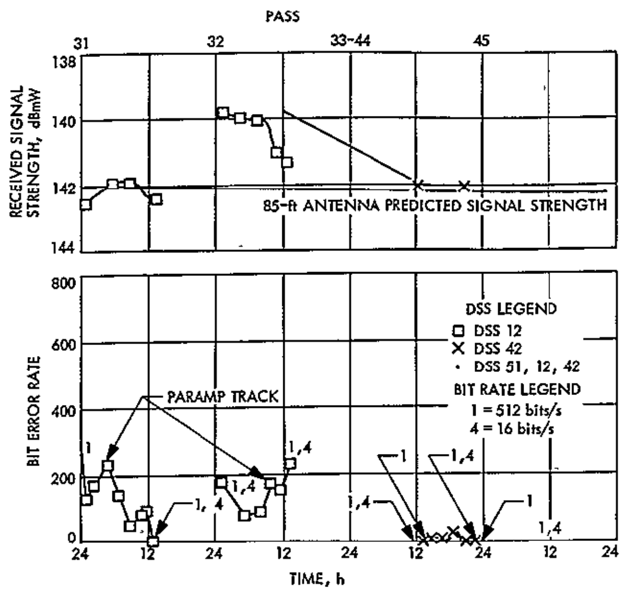


**Fig. 61. Received signal strength and bit error rate, passes 31–45**

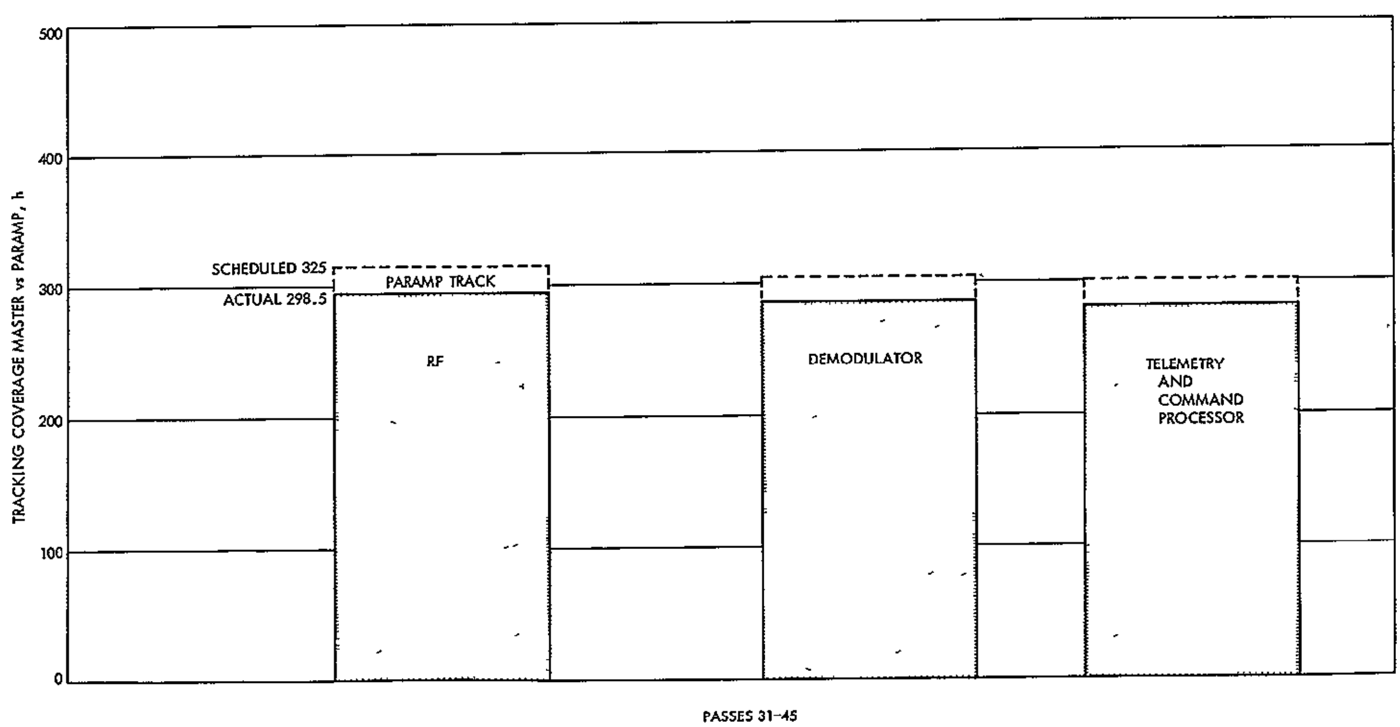


**Fig. 62. RF/demodulator/TCP performance history**

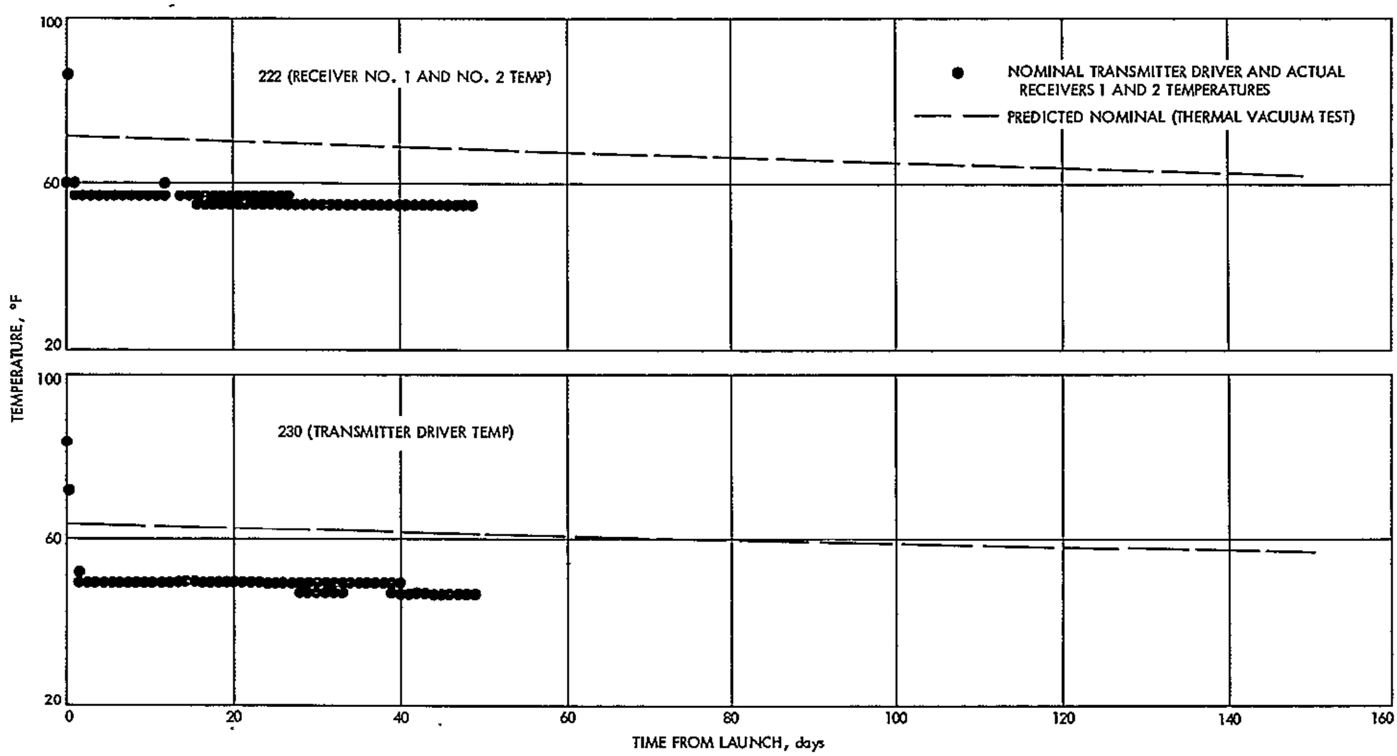


**Fig. 63. Spacecraft receiver and transmitter driver temperatures**

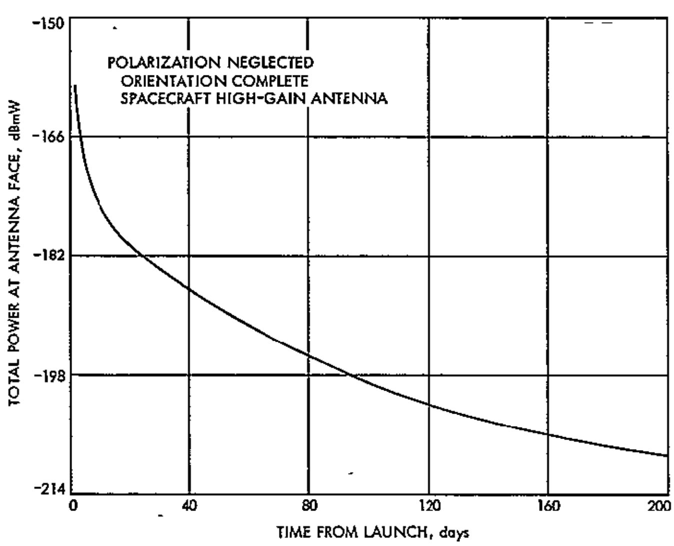


**Fig. 64. Predicted total power level at face of Deep Space Station antenna**

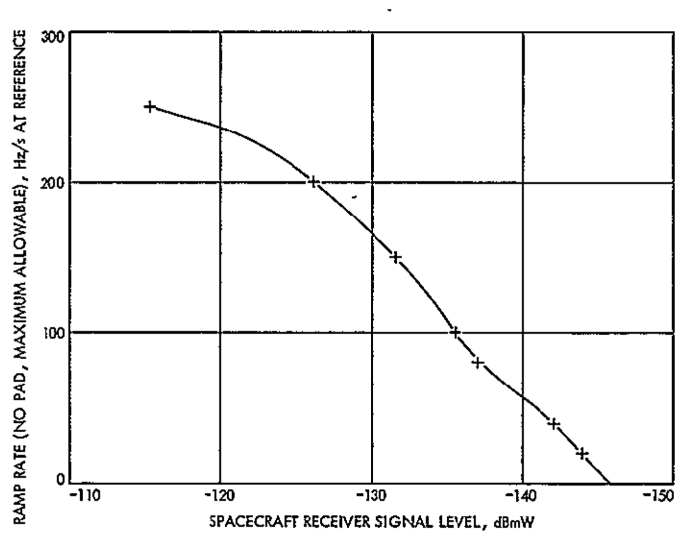


**Fig. 65. Spacecraft signal level vs tuning rate**

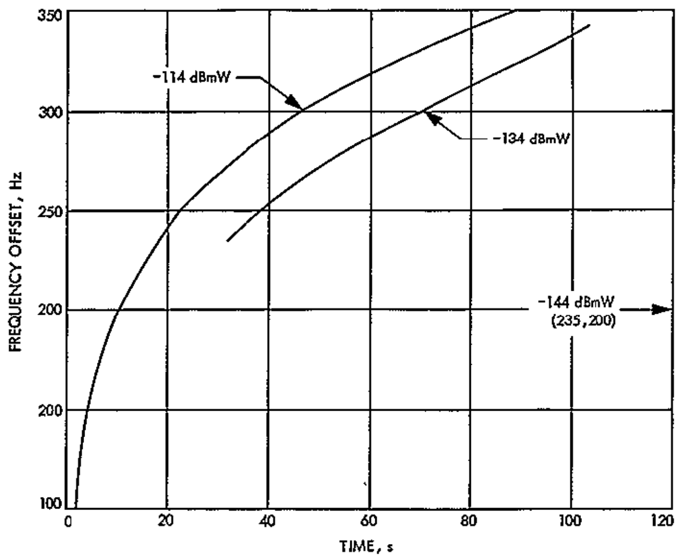


**Fig. 66. Channel 6 or channel 7 lockup time**

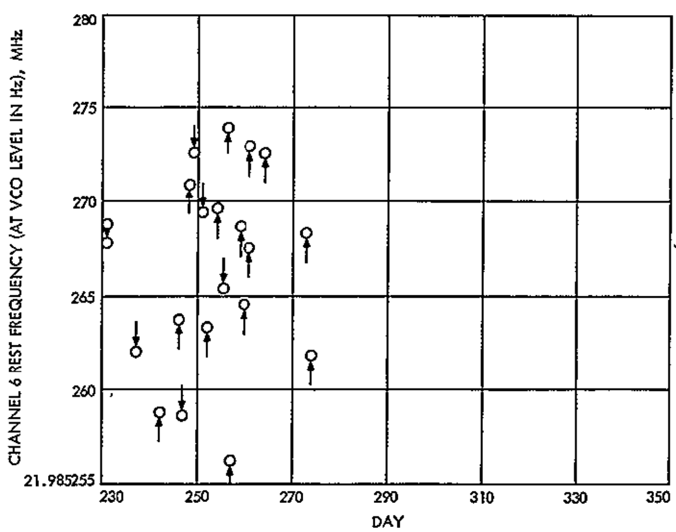


**Fig. 67. *Pioneer VII* rest frequency (channel 6)**

*d. Passes 46 through 191.* Since its launch on August 17, 1966, the *Pioneer VII* spacecraft has been continuously tracked by the Deep Space Stations for real-time telemetry coverage. The real-time telemetry coverage (at 8 bits/s) was predicted through April 1, 1967 on the Deep Space Station 85-ft antenna.

The information presented in this section is based on the net controller's logs, posttrack reports, engineering telemetry printouts, and tracking data printouts. Organization of the data is as follows:

(1) Tracking data summary (Table 40):

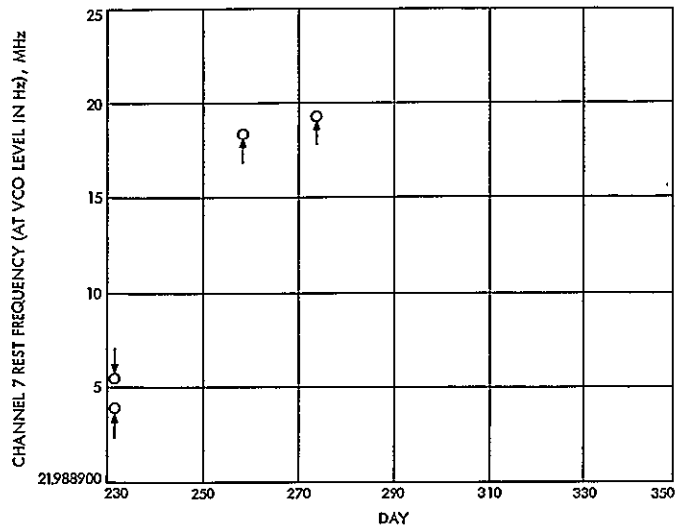


**Fig. 68. *Pioneer VII* rest frequency (channel 7)**

(a) When taken.

(b) Type.

(c) Amount.

(d) Qualitative statement based on near-real-time evaluation of teletype listing and definition of qualitative figure.

(2) RF performance:

(a) Downlink receiver signal strength (Table 41).

(b) Uplink signal strength (Fig. 69).

(c) Percent in lock vs actual scheduled (Figs. 70 and 71).

(d) Anomalies.

(3) Telemetry performance:

(a) Bit error rate (Table 42 and Figs. 72 and 73).

(b) Bit rate (Table 43).

(c) Percent demodulator/TCP in lock (Fig. 74).

(d) Anomalies.

(4) Command performance:

(a) Commands sent:

By station (Table 44).

Total (Figs. 75 and 76).

(b) Anomalies.

## Table 40. Metric data summary

| PAS | DSS | DAY | CODE | T1 | T2 | T2-T1 | FREQ | HA-1 | DEC-1 | QC | MLT | DT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 080 | 11 | 308/9 | 8040 | 010 | 755 | 465 | 21985570 | 286.3 | 2.610 | 10 | 02 | 60 |
| 085 | 11 | 313/4 | 8040 | 012 | 040 | 28 | 21985590 | 290.1 | 3.144 | 10 | 02 | 60 |
| 085 | 11 | 313/4 | 8040 | 041 | 047 | 6 | 21985590 | 297.5 | 3.122 | 10 | 02 | 06 |
| 085 | 11 | 313/4 | 8040 | 047 | 750 | 423 | 21985590 | 299.0 | 3.148 | 09 | 02 | 60 |
| 086 | 11 | 314/5 | 8040 | 2359 | 255 | 176 | 21985590 | 287.5 | 3.290 | 10 | 02 | 60 |
| 086 | 11 | 314/5 | 8040 | 344 | 748 | 244 | 21985590 | 343.8 | 3.214 | 10 | 02 | 60 |
| 087 | 11 | 315/6 | 8060 | 2331 | 2356 | 25 | 21985590 | 281.2 | 3.438 | 10 | 02 | 60 |
| 087 | 11 | 315/6 | 8040 | 030 | 615 | 345 | 21989230 | 295.9 | 3.324 | 09 | 02 | 60 |
| 087 | 11 | 315/6 | 8040 | 655 | 751 | 56 | 21989230 | 32.22 | 3.312 | 10 | 02 | 60 |
| 094 | 11 | 321/2 | 8050 | 059 | 1 1 | 2 | 21989270 | 307.0 | 4.250 | 09 | 02 | 10 |
| 094 | 11 | 321/2 | 8050 | 1 2 | 143 | 41 | 21989270 | 307.6 | 4.250 | 06 | 02 | 60 |
| 094 | 11 | 321/2 | 8040 | 3 1 | 829 | 328 | 21989270 | 333.7 | 4.188 | 10 | 02 | 60 |
| 094 | 11 | 322/3 | 8040 | 2355 | 820 | 505 | 21985620 | 291.5 | 4.416 | 10 | 02 | 60 |
| 098 | 11 | 326/7 | 8060 | 23 1 | 2316 | 15 | 21985630 | 280.4 | 5.070 | 10 | 02 | 60 |
| 098 | 11 | 326/7 | 8040 | 2346 | 823 | 517 | 21985630 | 291.7 | 5.044 | 09 | 02 | 60 |
| 099 | 11 | 327/8 | 8060 | 23 4 | 2341 | 37 | 21985640 | 281.6 | 5.224 | 10 | 02 | 60 |
| 099 | 11 | 327/8 | 8040 | 017 | 825 | 488 | 21989290 | 299.8 | 5.178 | 09 | 02 | 60 |
| 107 | 11 | 335/6 | 8060 | 2224 | 2248 | 24 | 21985660 | 275.8 | 6.598 | 10 | 02 | 60 |
| 107 | 11 | 335/6 | 8040 | 23 8 | 823 | 555 | 21985660 | 287.0 | 6.632 | 08 | 02 | 60 |
| 114 | 11 | 342/3 | 8040 | 038 | 120 | 42 | 21985680 | 312.9 | 7.864 | 09 | 02 | 60 |
| 114 | 11 | 342/3 | 8040 | 123 | 831 | 428 | 21985680 | 324.1 | 7.838 | 08 | 02 | 60 |
| 115 | 11 | 343/4 | 8140 | 23 9 | 040 | 91 | 21989340 | 291.2 | 7.956 | 08 | 02 | 60 |
| 115 | 11 | 343/4 | 8140 | 046 | 055 | 9 | 21989340 | 315.4 | 7.968 | 10 | 02 | 60 |
| 115 | 11 | 343/4 | 8040 | 1 2 | 816 | 434 | 21989340 | 319.4 | 8.024 | 07 | 02 | 60 |
| 117 | 11 | 345/6 | 8040 | 2238 | 855 | 617 | 21985690 | 284.4 | 8.452 | 09 | 02 | 60 |
| 148 | 11 | 011/2 | 8140 | 23 4 | 812 | 548 | 21985730 | 303.4 | 14.82 | 10 | 02 | 60 |
| 149 | 11 | 012/3 | 8140 | 2138 | 2335 | 117 | 21989390 | 282.3 | 15.10 | 10 | 02 | 60 |
| 149 | 11 | 012/3 | 8140 | 3 4 | 4 0 | 56 | 21989386 | 003.6 | 15.07 | 10 | 02 | 60 |
| 149 | 11 | 012/3 | 8140 | 519 | 6 5 | 46 | 21989386 | 037.3 | 15.07 | 10 | 02 | 60 |
| 149 | 11 | 012/3 | 8140 | 753 | 832 | 39 | 21969386 | 075.9 | 15.05 | 10 | 02 | 60 |
| 151 | 11 | 014/5 | 8140 | 2146 | 827 | 641 | 21985730 | 284.8 | 15.54 | 09 | 02 | 60 |
| 158 | 11 | 021/2 | 8140 | 2151 | 819 | 628 | 21989390 | 288.5 | 16.89 | 10 | 02 | 60 |

- **PASS** Pass number or number of times *Pioneer VII* has passed over station.
- **DSS** Station number: DSS 11, 12, 14 Goldstone, California; DSS 61, 62 Spain; DSS 41, 42 Australia; DSS 51 South Africa
- **DAY** Day of current year.
- **CODE** Data condition code for doppler data, e g , 8040, 8140 are good 2-way; 8050, 8150 are good 1-way; 8060, 8160 are good 3-way
- **T1** Beginning time of a data sample.
- **T2** Ending time of a data sample.
- **T2-T1** Number of good data points, in min.
- **FREQ** Transmitter reference frequency.
- **HA-1** Beginning hour angle (used in postpass reduction).
- **DEC-1** Beginning declination angle (used in postpass reduction).
- **QC** An index indicating completeness and usability of the data format. Ten is perfect; zero is unusable. Measured are overall effect of errors from poor teletype outage, errors due to transmission equipment, human errors in loading and stopping equipment, extra characters or shifts, and deletion or suppression of characters or shifts.
- **MLT** The station multiplier for doppler-counting. Times 1 or times 2 is possible. However times 2 is normal for *Pioneer*.
- **DT** Sampling interval, in s.

Table 40 (contd)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 11 | 023/4 | 8140 | 2238 | 430 | 352 | 21989390 | 300.8 | 17.33 | 05 | 02 | 60 |
| 164 | 11 | 027/8 | 8540 | 2220 | 2338 | 78 | 21989390 | 297.3 | 18.08 | 06 | 02 | 60 |
| 164 | 11 | 027/8 | 8540 | 051 | 422 | 211 | 21989390 | 335.2 | 17.97 | 06 | 02 | 60 |
| 180 | 11 | 043/4 | 8140 | 2121 | 748 | 627 | 21989390 | 282.0 | 20.56 | 07 | 02 | 60 |
| 181 | 11 | 044/5 | 8140 | 2345 | 454 | 309 | 21989390 | 323.3 | 20.71 | 09 | 02 | 60 |
| 181 | 11 | 044/5 | 8160 | 520 | 526 | 6 | 21989390 | 046.9 | 20.64 | 09 | 02 | 60 |
| 182 | 11 | 045/6 | 8160 | 2032 | 2056 | 24 | 21989390 | 275.3 | 20.85 | 08 | 02 | 60 |
| 182 | 11 | 045/6 | 8140 | 2138 | 552 | 494 | 21989390 | 291.8 | 20.86 | 08 | 02 | 60 |
| 42 | 12 | 271 | 8160 | 230 | 245 | 15 | 21985410 | 288.9 | 1.050 | 10 | 2 | 60 |
| 42 | 12 | 271 | 8140 | 3 9 | 10 9 | 420 | 21985410 | 298.6 | 1.032 | 10 | 2 | 60 |
| 43 | 12 | 272 | 8140 | 331 | 10 9 | 398 | 21985420 | 305.2 | 0.994 | 10 | 2 | 60 |
| 44 | 12 | 273 | 8160 | 114 | 130 | 16 | 21985420 | 272.1 | 1.112 | 10 | 2 | 60 |
| 44 | 12 | 273 | 8140 | 2 6 | 1253 | 647 | 21989060 | 284.9 | 1.046 | 10 | 2 | 60 |
| 46 | 12 | 275 | 8140 | 144 | 1225 | 641 | 21985420 | 281.6 | 0.996 | 10 | 2 | 60 |
| 48 | 12 | 277 | 8140 | 150 | 9 5 | 435 | 21985430 | 284.8 | 0.960 | 10 | 2 | 60 |
| 49 | 12 | 278 | 8140 | 126 | 1234 | 668 | 21985440 | 279.8 | 0.954 | 10 | 2 | 60 |
| 50 | 12 | 279 | 8140 | 3 1 | 11 7 | 486 | 21985450 | 304.5 | 0.920 | 10 | 2 | 60 |
| 51 | 12 | 280 | 8160 | 045 | 114 | 298 | 21985450 | 272.3 | 001.0 | 10 | 2 | 60 |
| 51 | 12 | 280 | 8140 | 144 | 9 0 | 436 | 21989090 | 286.2 | 0.92 | 10 | 2 | 60 |
| 53 | 12 | 282 | 8150 | 040 | 043 | 3 | 21985460 | 272.1 | 01.06 | 10 | 02 | 60 |
| 53 | 12 | 282 | 8140 | 127 | 1217 | 650 | 21985460 | 283.9 | 0.920 | 10 | 02 | 60 |
| 54 | 12 | 283 | 8140 | 1 2 | 848 | 466 | 21985460 | 278.5 | 0.954 | 10 | 02 | 60 |
| 56 | 12 | 285 | 8140 | 059 | 1159 | 660 | 21985470 | 279.6 | 0.984 | 09 | 2 | 60 |
| 58 | 12 | 287 | 8140 | 059 | 1158 | 659 | 21989110 | 281.4 | 0.948 | 10 | 02 | 60 |
| 60 | 12 | 289 | 8140 | 1 6 | 1124 | 618 | 21985480 | 285.0 | 0.990 | 10 | 02 | 60 |
| 63 | 12 | 292 | 8140 | 025 | 1143 | 678 | 21985490 | 277.2 | 1.158 | 10 | 02 | 60 |
| 65 | 12 | 294 | 8140 | 024 | 1135 | 671 | 21989140 | 278.6 | 1.300 | 09 | 02 | 60 |
| 66 | 12 | 295 | 8140 | 019 | 1125 | 666 | 21985510 | 324.6 | 01.22 | 09 | 02 | 60 |
| 068 | 12 | 296/7 | 8150 | 2349 | 2359 | 10 | 21985510 | 272.4 | 01.55 | 10 | 02 | 60 |
| 068 | 12 | 296/7 | 8140 | 020 | 1124 | 664 | 21985510 | 280.1 | 01.38 | 09 | 02 | 60 |
| 070 | 12 | 298/9 | 8140 | 050 | 1121 | 631 | 21989150 | 289.1 | 1.638 | 09 | 02 | 60 |
| 074 | 12 | 302/3 | 8140 | 2356 | 11 0 | 664 | 21985530 | 278.7 | 1.934 | 10 | 02 | 60 |
| 076 | 12 | 304/5 | 8140 | 027 | 11 0 | 633 | 21985540 | 287.8 | 2.094 | 10 | 02 | 60 |
| 078 | 12 | 306/7 | 8140 | 021 | 1052 | 631 | 21989190 | 287.7 | 2.240 | 10 | 02 | 60 |
| 120 | 12 | 348/9 | 8140 | 2221 | 9 8 | 647 | 21985685 | 281.6 | 9.026 | 10 | 02 | 60 |
| 121 | 12 | 349/0 | 8140 | 2346 | 259 | 193 | 21989350 | 303.2 | 9.224 | 09 | 02 | 60 |
| 121 | 12 | 349/0 | 8140 | 3 9 | 915 | 366 | 21989350 | 354.1 | 9.250 | 09 | 02 | 60 |
| 125 | 12 | 354 | 8140 | 1 2 | 910 | 488 | 21985700 | 324.0 | 10.04 | 09 | 02 | 60 |
| 126 | 12 | 354/5 | 8140 | 23 4 | 9 8 | 604 | 21985700 | 295.0 | 10.24 | 09 | 02 | 60 |
| 127 | 12 | 355/6 | 8160 | 2217 | 2315 | 58 | 21989360 | | | | 02 | 60 |
| 127 | 12 | 355/6 | 8140 | 2350 | 859 | 549 | 21989360 | | | 04 | 02 | 60 |
| 133 | 12 | 361 | 8140 | 23 0 | 0 6 | 66 | 21985710 | 296.8 | 11.68 | 10 | 02 | 60 |
| 135 | 12 | 363/4 | 8140 | 059 | 217 | 78 | 21989380 | 327.4 | 12.10 | 10 | 02 | 60 |
| 135 | 12 | 363/4 | 8140 | 252 | 857 | 365 | 21989380 | 355.7 | 12.12 | 10 | 02 | 60 |
| 142 | 12 | 005/6 | 8140 | 2155 | 825 | 630 | 21989390 | 284.1 | 13.55 | 10 | 02 | 60 |
| 143 | 12 | 007 | 8140 | 031 | 828 | 477 | 21985720 | 323.4 | 13.76 | 10 | 02 | 60 |
| 154 | 12 | 017/8 | 8140 | 2141 | 054 | 193 | 21989390 | 285.0 | 15.95 | 10 | 02 | 60 |
| 154 | 12 | 017/8 | 8140 | 136 | 342 | 126 | 21985730 | 343.5 | 15.96 | 09 | 02 | 60 |
| 154 | 12 | 017/8 | 8140 | 812 | 829 | 17 | 21985730 | 082.6 | 16.04 | 10 | 02 | 60 |
| 155 | 12 | 018/9 | 8140 | 2122 | 2251 | 89 | 21989390 | 280.3 | 16.15 | 10 | 02 | 60 |

Table 40 (contd)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 155 | 12 | 018/9 | 8150 | 2310 | 458 | 348 | 21989390 | 307.3 | 16.15 | 10 | 02 | 60 |
| 155 | 12 | 018/9 | 8150 | 631 | 713 | 42 | 21989390 | 057.6 | 16.22 | 10 | 02 | 60 |
| 155 | 12 | 018/9 | 8150 | 727 | 756 | 29 | 21989390 | 071.6 | 16.23 | 10 | 02 | 60 |
| 155 | 12 | 018/9 | 8140 | 759 | 8 7 | 8 | 21989390 | 079.6 | 16.25 | 10 | 02 | 60 |
| 156 | 12 | 019/0 | 8140 | 2122 | 439 | 437 | 21989415 | 280.6 | 16.35 | 10 | 02 | 60 |
| 156 | 12 | 019/0 | 8160 | 5 5 | 521 | 16 | 21989415 | 036.4 | 16.41 | 10 | 02 | 10 |
| 156 | 12 | 019/0 | 8160 | 612 | 821 | 129 | 21989415 | | | 10 | 02 | 10 |
| 161 | 12 | 024/5 | 8140 | 2139 | 441 | 422 | 21989390 | | | | 02 | 60 |
| 161 | 12 | 024/5 | 8140 | 459 | 817 | 198 | 21989390 | 036.5 | 17.32 | 10 | 02 | 60 |
| 163 | 12 | 026 | 8140 | 2225 | 2257 | 32 | 21989390 | 298.5 | 17.66 | 10 | 02 | 60 |
| 167 | 12 | 030/1 | 8140 | 2123 | 650 | 567 | 21989390 | 284.2 | 18.35 | 10 | 02 | 60 |
| 167 | 12 | 030/1 | 8160 | 726 | 813 | 47 | 21989390 | 075.2 | 18.45 | 10 | 02 | 60 |
| 45 | 14 | 274 | 8160 | 254 | 3 4 | 10 | 21985430 | 106.2 | 22.97 | 10 | 2 | 60 |
| 45 | 14 | 274 | 8050 | 311 | 814 | 303 | 21985430 | 109.2 | 26.27 | 08 | 2 | 60 |
| 45 | 14 | 274 | 8060 | .834 | 845 | 11 | 21985430 | 217.0 | 49.41 | 10 | 2 | 60 |
| 103 | 14 | 332 | 8050 | 321 | 4 2 | 41 | 21985650 | 156.9 | 58.40 | 08 | 02 | 60 |
| 103 | 14 | 332 | 8040 | 422 | 955 | 333 | 21985650 | 186.7 | 60.29 | | 02 | 60 |
| 140 | 14 | 003/4 | 8060 | 2059 | 2140 | 41 | 21985730 | 269.3 | 13.17 | 09 | 02 | 60 |
| 140 | 14 | 003/4 | 8040 | 22 9 | 23 3 | 54 | 21989380 | 286.7 | 13.13 | 09 | 02 | 60 |
| 140 | 14 | 003/4 | 8040 | 2359 | 8 3 | 484 | 21989380 | 314.2 | 13.14 | 10 | 02 | 60 |
| 140 | 14 | 003/4 | 8060 | 830 | 840 | 10 | 21989380 | 082.1 | 13.23 | 10 | 02 | 60 |
| 153 | 14 | 016/7 | 8040 | 2121 | 2215 | 54 | 21989390 | 279.3 | 15.75 | 10 | 02 | 60 |
| 153 | 14 | 016/7 | 8040 | 815 | 840 | 25 | 21989390 | 082.9 | 15.85 | 10 | 02 | 60 |
| 189 | 14 | 052 | 8040 | 2139 | 048 | 189 | 21989370 | 293.6 | 21.60 | 06 | 02 | 60 |
| 189 | 14 | 052 | 8040 | 210 | 423 | 133 | 21989370 | 001.3 | 21.62 | 06 | 02 | 60 |
| 43 | 42 | 271 | 8040 | 1031 | 18 7 | 456 | 21985410 | 315.3 | 1.042 | 09 | 2 | 60 |
| 44 | 42 | 272 | 8040 | 1029 | 1148 | 79 | 21985420 | 315.8 | 1.006 | 09 | 2 | 60 |
| 44 | 42 | 272 | 8050 | 1152 | 12 7 | 15 | 21985420 | 336.5 | 1.030 | 10 | 2 | 60 |
| 44 | 42 | 272 | 8040 | 1240 | 17 4 | 264 | 21985420 | 348.6 | 1.030 | 0 | 2 | 60 |
| 45 | 42 | 273 | 8060 | 1239 | 1254 | 15 | 21989060 | 349.4 | 0.988 | 10 | 2 | 60 |
| 45 | 42 | 273 | 8040 | 1320 | 18 4 | 284 | 21985420 | 359.6 | 01.00 | 08 | 2 | 60 |
| 46 | 42 | 274 | 8040 | 833 | 1714 | 521 | 21985420 | 288.7 | 0.920 | 09 | 2 | 60 |
| 47 | 42 | 275 | 8040 | 1241 | 18 4 | 323 | 21985430 | 351.8 | 0.960 | 09 | 2 | 60 |
| 48 | 42 | 276 | 8040 | 815 | 17 2 | 527 | 21985430 | 286.2 | 0.894 | 09 | 2 | 60 |
| 49 | 42 | 277 | 8040 | 930 | 1817 | 527 | 21985430 | 305.9 | 0.910 | 08 | 2 | 60 |
| 52 | 42 | 280 | 8040 | 16 0 | 18 5 | 125 | 21985450 | 046.5 | 0.900 | 10 | 2 | 60 |
| 141 | 42 | 004 | 8140 | 832 | 1337 | 305 | 21989380 | 348.5 | 13.26 | 09 | 02 | 60 |
| 156 | 42 | 019 | 8140 | 933 | 954 | 21 | 21989400 | 008.9 | 16.27 | 10 | 02 | 60 |
| 156 | 42 | 019 | 8140 | 1010 | 1336 | 206 | 21989390 | 018.2 | 16.28 | 10 | 02 | 60 |
| 157 | 42 | 020 | 8140 | 515 | 833 | 198 | 21989375 | 304.7 | 16.35 | 09 | 02 | 60 |
| 157 | 42 | 020 | 8140 | 848 | 921 | 33 | 21989390 | 358.0 | 16.39 | 09 | 02 | 60 |
| 157 | 42 | 020 | 8140 | 949 | 11 2 | 73 | 21989390 | 013.3 | 16.40 | 09 | 02 | 60 |
| 157 | 42 | 020 | 8140 | 1138 | 1216 | 38 | 21989390 | 040.5 | 16.41 | 09 | 02 | 60 |
| 160 | 42 | 023 | 8140 | 625 | 1322 | 417 | 21989390 | 323.2 | 17.03 | 08 | 02 | 60 |
| 161 | 42 | 024 | 8140 | 539 | 1248 | 429 | 21989390 | 312.0 | 17.20 | 07 | 02 | 60 |
| 163 | 42 | 026 | 8140 | 519 | 1311 | 472 | 21989390 | 307.6 | 17.56 | 09 | 02 | 60 |
| 168 | 42 | 031 | 8140 | 723 | 1311 | 348 | 21989390 | 340.1 | 18.49 | 09 | 02 | 60 |
| 171 | 42 | 035 | 8140 | 210 | 722 | 312 | 21989400 | 357.0 | 19.19 | 06 | 02 | 60 |
| 174 | 42 | 037 | 8140 | 534 | 1235 | 421 | 21989400 | 314.5 | 19.37 | 10 | 02 | 60 |
| 175 | 42 | 038 | 8160 | 439 | 658 | 139 | 21989400 | 301.0 | 19.50 | 10 | 02 | 60 |

Table 40 (contd)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 175 | 42 | 038 | 8140 | 723 | 1126 | 243 | 21989400 | 342.0 | 19.55 | 09 | 02 | 60 |
| 176 | 42 | 039 | 8140 | 5 7 | 13 5 | 478 | 21989390 | 308.2 | 19.68 | 10 | 02 | 60 |
| 179 | 42 | 042 | 8140 | 513 | 1254 | 461 | 21989390 | 310.5 | 20.13 | 09 | 02 | 60 |
| 180 | 42 | 043 | 8140 | 516 | 1251 | 455 | 21989390 | 311.2 | 20.28 | 09 | 02 | 60 |
| 182 | 42 | 045 | 8140 | 522 | 1235 | 433 | 21989390 | 313.5 | 20.56 | 09 | 02 | 60 |
| 185 | 42 | 048 | 8140 | 518 | 1217 | 419 | 21989380 | 313.2 | 20.97 | 09 | 02 | 60 |
| 186 | 42 | 049 | 8140 | 454 | 1219 | 445 | 21989380 | 307.4 | 21.10 | 09 | 02 | 60 |
| 189 | 42 | 052 | 8140 | 454 | 1149 | 415 | 21989370 | 308.1 | 21.46 | 08 | 02 | 60 |
| 190 | 42 | 053 | 8140 | 536 | 1214 | 398 | 21989370 | 318.9 | 21.59 | 09 | 02 | 60 |
| 191 | 42 | 054 | 8140 | 6 0 | 1244 | 404 | 21989370 | | | 08 | 02 | 60 |
| 154 | 62 | 017/8 | 8140 | 1424 | 1619 | 115 | 21989380 | 287.8 | 15.90 | 07 | 01 | 60 |
| 164 | 62 | 027/8 | 8140 | 14 4 | 1752 | 228 | 21989390 | 285.9 | 17.78 | 09 | 02 | 60 |
| 164 | 62 | 027/8 | 8040 | 1753 | 21 6 | 193 | 21989390 | 343.1 | 17.79 | 08 | 02 | 60 |
| 164 | 62 | 027/8 | 8060 | 2129 | 2343 | 134 | 21989390 | 037.1 | 17.79 | 08 | 02 | 60 |
| 42 | 51 | 27071 | 8040 | 1826 | 244 | 498 | 21985410 | 312.0 | 0.986 | 06 | 01 | 60 |
| 43 | 51 | 27172 | 8040 | 1832 | 3 9 | 517 | 21985420 | 314.5 | 0.958 | 06 | 01 | 60 |
| 44 | 51 | 27273 | 8040 | 1732 | 133 | 481 | 21985420 | 300.5 | 0.902 | 05 | 01 | 60 |
| 45 | 51 | 27374 | 8040 | 1827 | 3 7 | 520 | 21985420 | 315.3 | 0.914 | 07 | 01 | 60 |
| 46 | 51 | 27475 | 8040 | 1735 | 112 | 457 | 21985420 | 303.2 | 0.884 | 07 | 01 | 60 |
| 47 | 51 | 27576 | 8040 | 1826 | 3 9 | 523 | 21985430 | 317.2 | 0.878 | 07 | 01 | 60 |
| 51 | 51 | 27980 | 8040 | 1855 | 115 | 380 | 21985450 | 34.81 | 0.850 | 8 | 01 | 60 |
| 52 | 51 | 280/1 | 8040 | 1830 | 243 | 493 | 21985450 | 322.9 | 0.818 | 06 | 1 | 60 |
| 59 | 51 | 287/8 | 8040 | 1525 | 215 | 650 | 21985480 | 283.1 | 0.822 | 06 | 1 | 60 |
| 61 | 51 | 289/0 | 8040 | 18 2 | 2.1 | 479 | 21985490 | 324.0 | 0.984 | 05 | 1 | 60 |
| 72 | 51 | 300 | 8050 | 1458 | 15 1 | 3 | 1-WAY | | | | | |
| 72 | 51 | 300 | 8040 | 1528 | 2055 | 327 | 21985530 | 294.3 | 1.572 | 08 | 1 | 60 |
| 80 | 51 | 308 | 8040 | 1450 | 1923 | 273 | 21985570 | N/AV | N/AV | 07 | 1 | 60 |
| 80 | 51 | 308 | 8040 | 1951 | 2048 | 57 | 21985570 | 5.886 | 2.420 | 06 | 1 | 60 |
| 82 | 51 | 310 | 8040 | 1426 | 1651 | 145 | 21985570 | 285.9 | 2.482 | | 1 | 60 |
| 85 | 51 | 313 | 8040 | 1426 | 2342 | 556 | 21985580 | 288.0 | 2.876 | 06 | 1 | 60 |
| 86 | 51 | 314 | 8050 | 1349 | 1356 | 7 | 1-WAY | | | | | |
| 86 | 51 | 314 | 8040 | 1445 | 2339 | 534 | 21985590 | 293.4 | 3.044 | 08 | 1 | 60 |
| 87 | 51 | 315 | 8040 | 14 9 | 2359 | 590 | 21985590 | 285.1 | 3.112 | | 1 | 60 |
| 90 | 51 | 318/9 | 8040 | 1513 | 044 | 571 | 21985600 | 302.9 | 3.568 | 08 | 2 | 60 |
| 91 | 51 | 319/0 | 8040 | 14 9 | 032 | 623 | 21985610 | 287.5 | 3.668 | 06 | 01 | 60 |
| 92 | 51 | 320 | 8040 | 14 7 | 1859 | 292 | 21985610 | 287.9 | 3.806 | 05 | 01 | 60 |
| 92 | 51 | 320 | 8050 | 19 5 | 1915 | 10 | 1-WAY | | | 10 | 01 | 60 |
| 92 | 51 | 320/1 | 8040 | 1925 | 0 7 | 282 | 21985610 | 7.242 | 3.930 | 06 | 01 | 60 |
| 093 | 51 | 321 | 8050 | 1334 | 1341 | 7 | 1-WAY | | | | | |
| 93 | 51 | 321 | 8040 | 14 9 | 2320 | 551 | 21985610 | 288.8 | 4.022 | 05 | 01 | 60 |
| 094 | 51 | 322 | 8040 | 1410 | 2328 | 558 | 21985620 | 289.1 | 4.164 | 07 | 1 | 60 |
| 096 | 51 | 324 | 8040 | 1424 | 2356 | 572 | 21985620 | 294.2 | 4.474 | 06 | 1 | 60 |
| 097 | 51 | 325 | 8050 | 1328 | 1340 | 12 | 1-WAY | | | | | |
| 097 | 51 | 325 | 8040 | 1354 | 2354 | 600 | 21985630 | 287.4 | 4.666 | 07 | 01 | 60 |
| 098 | 51 | 326 | 8040 | 14 0 | 2317 | 557 | 21985630 | 289.8 | 4.756 | 07 | 1 | 60 |
| 099 | 51 | 327 | 8040 | 14 0 | 2344 | 584 | 21985630 | 290.0 | 4.924 | 07 | 01 | 60 |
| 105 | 51 | 333 | 8040 | 14 0 | 2232 | 512 | 21985650 | 293.2 | 5.970 | 06 | 01 | 60 |
| 105 | 51 | 333 | 8040 | 2328 | 2356 | 28 | 21985650 | 075.3 | 6.018 | 09 | 01 | 60 |
| 106 | 51 | 334 | 8040 | 1415 | 2349 | 574 | 21985650 | 297.5 | 6.214 | 05 | 01 | 60 |
| 107 | 51 | 335 | 8040 | 14 9 | 2246 | 517 | 21985660 | 296.7 | 6.394 | 09 | 01 | 60 |

Table 40 (contd)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 108 | 51 | 336 | 8140 | 1353 | 2259 | 546 | 21985660 | 293.1 | 6.544 | 07 | 01 | 60 |
| 111 | 51 | 339 | 8140 | 1340 | 2340 | 600 | 21985670 | 291.2 | 7.102 | 09 | 01 | 60 |
| 112 | 51 | 340 | 8140 | 1326 | 2339 | 613 | 21985670 | 293.2 | 07.32 | 09 | 01 | 60 |
| 113 | 51 | 341 | 8140 | 1357 | 2335 | 578 | 21985680 | 296.5 | 7.518 | 08 | 01 | 60 |
| 114 | 51 | 342 | 8140 | 1338 | 2344 | 606 | 21985680 | 292.5 | 7.676 | 06 | 01 | 60 |
| 115 | 51 | 343 | 3140 | 1335 | 2235 | 540 | 21985680 | 292.1 | 7.894 | 09 | 01 | 60 |
| 116 | 51 | 344 | 8140 | 1321 | 2050 | 449 | 21985680 | 289.0 | 8.048 | 08 | 01 | 60 |
| 117 | 51 | 345 | 8140 | 1338 | 2148 | 490 | 21985690 | 293.7 | 8.282 | 09 | 01 | 60 |
| 118 | 51 | 346 | 8140 | 1458 | 2318 | 500 | 21985690 | 314.2 | 8.520 | 09 | 01 | 60 |
| 119 | 51 | 347 | 8140 | 1337 | 2320 | 583 | 21985690 | 294.4 | 8.692 | 10 | 01 | 60 |
| 120 | 51 | 348 | 8140 | 1331 | 1422 | 51 | 21985675 | 293.6 | 8.870 | 10 | 01 | 60 |
| 120 | 51 | 348 | 8140 | 1437 | 2149 | 432 | 21985675 | 309.9 | 8.866 | 07 | 01 | 60 |
| 121 | 51 | 349 | 8140 | 1330 | 23 9 | 579 | 21985690 | 293.5 | 9.072 | 08 | 01 | 60 |
| 122 | 51 | 350 | 8140 | 1326 | 2311 | 585 | 21985700 | 293.0 | 9.258 | 07 | 01 | 60 |
| 124 | 51 | 352 | 8140 | 1322 | 2314 | 592 | 21985690 | 292.9 | 9.688 | 07 | 01 | 60 |
| 125 | 51 | 353 | 8140 | 1316 | 2316 | 600 | 21985690 | 291.9 | 9.896 | 09 | 01 | 60 |
| 126 | 51 | 354 | 8140 | 1320 | 2235 | 555 | 21985700 | 293.3 | 10.08 | 03 | 01 | 60 |
| 135 | 51 | 363 | 8140 | 1322 | 2244 | 562 | 21985710 | 297.5 | 11.98 | 07 | 01 | 60 |
| 136 | 51 | 364 | 8140 | 1313 | 2234 | 561 | 21985710 | 295.6 | 12.19 | 10 | 01 | 60 |
| 140 | 51 | 003 | 8140 | 13 3 | 2033 | 450 | 21985720 | 294.7 | 13.00 | 08 | 01 | 60 |
| 127 | 51 | 355 | 8140 | 1327 | 2132 | 485 | 21985700 | 295.4 | 10.30 | 09 | 01 | 60 |
| 128 | 51 | 356 | 8140 | 1311 | 2256 | 585 | 21985700 | 291.9 | 10.50 | 08 | 01 | 60 |
| 133 | 51 | 361 | 8140 | 13 6 | 2146 | 520 | 21985710 | 292.9 | 11.54 | 08 | 01 | 60 |
| 133 | 51 | 361 | 8140 | 2158 | 22 4 | 6 | 21985710 | 065.7 | 11.59 | 10 | 01 | 60 |
| 133 | 51 | 361 | 8160 | 22 5 | 2213 | 8 | 21985710 | 067.5 | 11.59 | 10 | 01 | 60 |
| 134 | 51 | 362 | 8140 | 1323 | 2153 | 510 | 21985710 | 297.3 | 11.77 | 08 | 01 | 60 |
| 141 | 51 | 004 | 8140 | 14 9 | 2219 | 490 | 21989380 | 311.8 | 13.24 | 10 | 01 | 60 |
| 142 | 51 | 005 | 8140 | 1352 | 2127 | 455 | 21985720 | 307.7 | 13.43 | 08 | 01 | 60 |
| 145 | 51 | 008 | 8140 | 1258 | 22-6 | 548 | 21985720 | 295.2 | 14.03 | 08 | 01 | 60 |
| 146 | 51 | 009 | 8140 | 1350 | 2112 | 442 | 21985720 | 308.5 | 14.24 | 09 | 01 | 60 |
| 147 | 51 | 010 | 8140 | 1255 | 2212 | 557 | 21985730 | 295.2 | 14.42 | 10 | 01 | 60 |
| 148 | 51 | 011 | 8140 | 1325 | 2149 | 504 | 21985730 | 303.0 | 14.64 | 10 | 01 | 60 |
| 151 | 51 | 014 | 8140 | 1245 | 2119 | 514 | 21985730 | 294.1 | 15.23 | 08 | 01 | 60 |
| 153 | 51 | 016 | 8140 | 1247 | 2050 | 483 | 21989390 | 293.3 | 15.59 | 07 | 01 | 60 |
| 157 | 51 | 020 | 8140 | 1250 | 1344 | 54 | 21989400 | 297.4 | 16.40 | 10 | 01 | 60 |
| 157 | 51 | 020 | 8140 | 1633 | 18 3 | 90 | 21989400 | 353.1 | 16.49 | 10 | 01 | 60 |
| 159 | 51 | 022 | 8140 | 1241 | 2144 | 543 | 21989390 | 295.8 | 16.77 | 06 | 01 | 60 |
| 162 | 51 | 025 | 8140 | 1233 | 1454 | 141 | 21989390 | 294.6 | 17.32 | 08 | 01 | 60 |
| 162 | 51 | 025 | 8160 | 1524 | 1542 | 18 | 21989390 | 337.4 | 17.41 | 09 | 01 | 60 |
| 162 | 51 | 025 | 8140 | 1556 | 2049 | 293 | 21989390 | 345.5 | 17.41 | 07 | 01 | 60 |
| 162 | 51 | 025 | 8160 | 21 8 | 2144 | 36 | 21989390 | 063.4 | 17.38 | 10 | 01 | 60 |
| 166 | 51 | 029 | 8140 | 1236 | 2123 | 527 | 21989390 | 296.6 | 18.05 | 09 | 01 | 60 |
| 167 | 51 | 030 | 8140 | 1257 | 2049 | 472 | 21989390 | 302.0 | 18.25 | 08 | 01 | 60 |
| 174 | 51 | 037 | 8160 | 1151 | 1242 | 51 | 21989400 | 287.6 | 19.31 | 10 | 01 | 60 |
| 174 | 51 | 037 | 8140 | 13 6 | 21 9 | 483 | 21989400 | 306.3 | 19.42 | 08 | 01 | 60 |
| 178 | 51 | 041 | 8140 | 1313 | 21 1 | 468 | 21989390 | 309.0 | 20.05 | 10 | 01 | 60 |
| 178 | 51 | 041 | 8160 | 1147 | 1241 | 54 | 21989390 | 287.6 | 19.99 | 10 | 01 | 60 |
| 181 | 51 | 044 | 8140 | 1217 | 2059 | 522 | 21989390 | | | 09 | 01 | 60 |
| 182 | 51 | 045 | 8140 | 13 9 | 2046 | 457 | 21989390 | 309.0 | 20.61 | 09 | 01 | 60 |
| 183 | 51 | 046 | 8140 | 1320 | 1852 | 332 | 21989380 | 312.0 | 20.76 | 06 | 01 | 60 |

Table 40 (contd)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 184 | 51 | 047 | 8140 | 13 1 | 2048 | 467 | 21989380 | 307.4 | 20.89 | 09 | 01 | 60 |
| 185 | 51 | 048 | 8160 | 1145 | 1226 | 41 | 21989357 | 288.8 | 20.95 | 08 | 01 | 60 |
| 185 | 51 | 048 | 8140 | 1254 | 2049 | 475 | 21989380 | 306.0 | 21.04 | 09 | 01 | 60 |
| 186 | 51 | 049 | 8160 | 1144 | 1227 | 43 | 21989380 | 288.8 | 21.06 | 09 | 01 | 60 |
| 186 | 51 | 049 | 8140 | 1255 | 2055 | 480 | 21989380 | 306.4 | 21.15 | 06 | 01 | 60 |
| 189 | 51 | 052 | 8160 | 1049 | 1157 | 68 | 21989370 | 000.0 | 334.1 | 09 | 01 | 60 |
| 189 | 51 | 052 | 8140 | 1230 | 2046 | 496 | 21989370 | 300.8 | 21.51 | 08 | 01 | 60 |
| 190 | 51 | 053 | 8140 | 1252 | 2042 | 470 | 21989370 | 306.6 | 21.64 | 09 | 01 | 60 |

Table 41. Downlink receiver signal strength

| Pass | Station | Day | Predicted signal strength, dBmW | Average receiver signal strength, dBmW | Configuration | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tracking loop bandwidth, HZ | Maser or paramplifier configuration | Threshold, dBmW |
| 46 | 42 | 274 | −142.2 | −143.0 | 12 | Maser | −175 |
| 46 | 51 | 274/5 | −142.2 | −142.8 | 12 | Maser | −171 |
| 46 | 12 | 275 | −142.2 | −142.8 | 12 | Maser | −173 |
| 47 | 42 | 275 | −142.3 | −143.1 | 12 | Maser | −174 |
| 47 | 51 | 275/6 | −142 3 | −142.4 | 12 | Maser | −171 |
| 48 | 42 | 276 | −142.6 | −143.5 | 12 | Maser | −174 |
| 48 | 12 | 277 | −142 6 | −143.1 | 12 | Maser | −173 |
| 49 | 42 | 277 | −143.1 | −143.1 | 12 | Maser | −174 |
| 49 | 12 | 278 | −143.1 | −143.2 | 12 | Maser | −172 |
| 50 | 12 | 279 | −143.3 | −143.2 | 12 | Maser | −173 |
| 51 | 51 | 279/0 | −143 5 | −143.3 | 12 | Maser | −171 |
| 51 | 12 | 280 | −143.5 | −143.9 | 12 | Maser | — |
| 52 | 42 | 280 | −143.7 | −144.0 | 12 | Maser | −174 |
| 52 | 51 | 280/1 | −143.7 | −144.3 | 12 | Maser | −171 |
| 53 | 12 | 282 | −144.0 | −143.8 | 12 | Maser | — |
| 54 | 12 | 283 | −144.2 | −144.7 | 12 | Maser | — |
| 56 | 12 | 285 | −144.4 | −144.9 | 12 | Maser | −172 |
| 58 | 12 | 287 | −144.7 | −145.4 | 12 | Maser | — |
| 59 | 51 | 287/8 | −145.0 | −145.6 | 12 | Maser | −171 |
| 60 | 12 | 289 | −145.3 | −146.0 | 12 | Maser | −171 |
| 61 | 41 | 289 | −145.5 | −146.0 | 12 | Maser | — |
| 61 | 51 | 289/0 | −145 5 | −146.0 | 12 | Maser | −171 |
| 63 | 12 | 292 | −146.0 | −148.8 | 12 | Maser | −172 |
| 65 | 12 | 294 | −146 5 | −147.1 | 12 | Maser | — |
| 66 | 12 | 295 | −146.8 | −147.1 | 12 | Maser | −172 |
| 68 | 12 | 296/7 | −147.2 | −148.4 | 12 | Maser | −171 |
| 70 | 12 | 298/9 | −147.6 | −148.0 | 12 | Maser | −172 |

Table 41 (contd)

| Pass | Station | Day | Predicted signal strength, dBmW | Average receiver signal strength, dBmW | Configuration | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tracking loop bandwidth, HZ | Maser or paramplifier configuration | Threshold, dBmW |
| 72 | 51 | 300 | −147.9 | −149.0 | 12 | Maser | −171 |
| 74 | 12 | 302/3 | −148.2 | −149.0 | 12 | Maser | −172 |
| 76 | 12 | 304/5 | −148.6 | −147.0 | 12 | Maser | −175 |
| 78 | 12 | 306/7 | −149.1 | −148.0 | 12 | Maser | −173 |
| 80 | 51 | 308/9 | −149.5 | −149.6 | 12 | Maser | −170 |
| 80 | 11 | 308/9 | −149.5 | −150.1 | 12 | Maser | −171 |
| 82 | 51 | 310 | −149.8 | −151.1 | 12 | Maser | −171 |
| 85 | 11 | 313/4 | −150.3 | −146.0 | 12 | Maser | −168 |
| 86 | 51 | 314/5 | −150.5 | −151.3 | 12 | Maser | −170 |
| 86 | 11 | 314/5 | −150.5 | −151.6 | 12 | Maser | −171 |
| 87 | 51 | 315 | −150.7 | −152.0 | 12 | Maser | −170 |
| 87 | 11 | 316 | −150.7 | −151.0 | 12 | Maser | −168 |
| 90 | 51 | 318/9 | −151 3 | −151.2 | 12 | Maser | −170 |
| 91 | 51 | 319/0 | −151.5 | −152.0 | 12 | Maser | −170 |
| 92 | 51 | 320/1 | −151.7 | −152.0 | 12 | Maser | −170 |
| 93 | 51 | 321/2 | −151.9 | −153.1 | 12 | Maser | −169 |
| 93 | 11 | 322 | −151.9 | −154.5 | 12 | Maser | −172 |
| 94 | 51 | 322 | −152.0 | −153.1 | 12 | Maser | −169 |
| 94 | 11 | 323 | −152.0 | −153.0 | 12 | Maser | −171 |
| 96 | 51 | 324/5 | −152.3 | −152.7 | 12 | Maser | −169 |
| 97 | 51 | 325 | −152.4 | −153.2 | 12 | Maser | −169 |
| 98 | 51 | 326 | −152.6 | −153.1 | 12 | Maser | −170 |
| 98 | 11 | 326/7 | −152.6 | −153.0 | 12 | Maser | −172 |
| 99 | 51 | 327 | −152.8 | −153.8 | 12 | Maser | −170 |
| 99 | 11 | 327/8 | −152.8 | −151.5 | 12 | Maser | −168 |
| 101 | 51 | 329 | −153.2 | −153.6 | 12 | Maser | −170 |
| 103 | 14 | 332 | −153.5 | −143.6 | 12 | Maser | −173 |
| 105 | 51 | 333 | −153.7 | −155 0 | 12 | Maser | −171 |
| 106 | 51 | 334 | −153.9 | −154 6 | 12 | Maser | −171 |
| 107 | 51 | 335 | −154.1 | −155.6 | 12 | Maser | −169 |
| 107 | 11 | 335/6 | −154.1 | −155.0 | 12 | Maser | −173 |
| 108 | 51 | 336 | −154 3 | −155 0 | 12 | Maser | −171 |
| 108 | 11 | 336/7 | −154.3 | −153.0 | 12 | Maser | — |
| 111 | 51 | 339 | −154 7 | −155.0 | 12 | Maser | −170 |
| 112 | 51 | 340 | −154.9 | −155.1 | 12 | Maser | −169 |
| 113 | 51 | 341 | −155.0 | −156.5 | 12 | Maser | −169 |
| 114 | 51 | 342 | −155.2 | −155.5 | 12 | Maser | −170 |
| 114 | 11 | 343 | −155.2 | −154.4 | 12 | Maser | −169 |

Table 41 (contd)

| Pass | Station | Day | Predicted signal strength, dBmW | Average receiver signal strength, dBmW | Configuration | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tracking loop bandwidth, HZ | Maser or paramplifier configuration | Threshold, dBmW |
| 115 | 51 | 343 | −155.3 | −155.5 | 12 | Maser | −169 |
| 115 | 11 | 344 | −155.3 | −156.5 | 12 | Maser | −170 |
| 116 | 51 | 344 | −155.4 | −155.7 | 12 | Maser | −169 |
| 117 | 51 | 345 | −155.6 | −156.0 | 12 | Maser | −169 |
| 117 | 11 | 345/6 | −155.6 | −156.3 | 12 | Maser | −171 |
| 118 | 51 | 346 | −155.7 | −158.3 | 12 | Maser | −169 |
| 119 | 51 | 347 | −155.8 | −156.1 | 12 | Maser | −170 |
| 120 | 51 | 348 | −156.0 | −156.5 | 12 | Maser | −171 |
| 120 | 12 | 348/9 | −156.0 | −156.7 | 12 | Maser | −171 |
| 121 | 51 | 349 | −156.1 | −156.6 | 12 | Maser | −169 |
| 121 | 12 | 349/0 | −156.1 | −156.7 | 12 | Maser | −171 |
| 122 | 51 | 350 | −156.2 | −156.3 | 12 | Maser | −169 |
| 124 | 51 | 352 | −156.4 | −156.6 | 12 | Maser | −169 |
| 125 | 51 | 353 | −156.5 | −157.4 | 12 | Maser | −170 |
| 125 | 12 | 354 | −156.5 | −157.7 | 12 | Maser | −172 |
| 126 | 51 | 354 | −156.6 | −157.8 | 12 | Maser | −171 |
| 126 | 12 | 354/5 | −156.6 | −157.4 | 12 | Maser | −172 |
| 127 | 51 | 355 | −156.7 | −157.5 | 12 | Maser | −171 |
| 127 | 12 | 355/6 | −156.7 | −158.0 | 12 | Maser | −173 |
| 128 | 51 | 356 | −156.8 | −157.4 | 12 | Maser | −169 |
| 133 | 51 | 361 | −157.3 | −157.6 | 12 | Maser | −169 |
| 133 | 12 | 361/2 | −157.4 | −160.0 | 12 | Maser | −167 |
| 134 | 51 | 362 | −157.5 | −158.5 | 12 | Maser | −169 |
| 135 | 12 | 363/4 | −157.6 | −158.3 | 12 | Maser | −173 |
| 135 | 51 | 363 | −157.6 | −158.6 | 12 | Maser | −169 |
| 136 | 51 | 364 | −158.0 | −159.1 | 12 | Maser | −169 |
| 140 | 51 | 003 | −158.1 | −160.0 | 12 | Maser | −169 |
| 140 | 14 | 003/4 | −148.1 | −149.0 | 12 | Maser | −173 |
| 141 | 42 | 004 | −158.2 | −157.3 | 12 | Maser | −172 |
| 141 | 51 | 004 | −158.2 | −158.8 | 12 | Maser | −169 |
| 141 | 12 | 004/5 | −158.2 | −158.7 | 12 | Maser | −172 |
| 142 | 42 | 005 | −158.3 | −158.6 | 12 | Maser | −172 |
| 142 | 51 | 005 | −158.3 | −159.0 | 12 | Maser | −169 |
| 142 | 12 | 005 | −158.3 | −158.8 | 12 | Maser | −173 |
| 143 | 51 | 006 | −158.4 | −159.4 | 12 | Maser | −169 |
| 143 | 12 | 007 | −158.4 | −158.7 | 12 | Maser | −172 |
| 145 | 51 | 008 | −158.5 | −159.4 | 12 | Maser | −169 |
| 146 | 51 | 009 | −158.5 | −160.6 | 12 | Maser | −169 |
| 146 | 11 | 009/0 | −158.5 | −159.1 | 12 | Maser | −170 |

Table 41 (contd)

| Pass | Station | Day | Predicted signal strength, dBmW | Average receiver signal strength, dBmW | Configuration | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tracking loop bandwidth, HZ | Maser or paramplifier configuration | Threshold, dBmW |
| 147 | 51 | 010 | −158 6 | −160.7 | 12 | Maser | −168 |
| 148 | 41 | 011 | −158.7 | −159.5 | 12 | Maser | −171 |
| 148 | 51 | 011 | −158.7 | −161.0 | 12 | Maser | −169 |
| 148 | 11 | 011/2 | −158.8 | −159.5 | 12 | Maser | −172 |
| 149 | 11 | 012/3 | −158.9 | −158.6 | 12 | Maser | −171 |
| 151 | 51 | 014 | −159.0 | −160.4 | 12 | Maser | −168 |
| 151 | 11 | 014/5 | −159.0 | −161.3 | 12 | Maser | −170 |
| 153 | 51 | 016 | −159.0 | −160.2 | 12 | Maser | −169 |
| 153 | 14 | 016/7 | −149.0 | −150 3 | 12 | Maser | −172 |
| 154 | 62 | 017 | −159.0 | −165.6 | 12 | Maser | −173 |
| 154 | 12 | 017/8 | −159.1 | −159 6 | 12 | Maser | −172 |
| 155 | 12 | 018/9 | −159.1 | −161.0 | 12 | Maser | −173 |
| 156 | 42 | 019 | −159.2 | −160.2 | 12 | Maser | −172 |
| 156 | 12 | 019/0 | −159.2 | −161.5 | 12 | Maser | −173 |
| 157 | 42 | 020 | −159.3 | −161.5 | 12 | Maser | −173 |
| 157 | 41 | 020 | −159.3 | −159.0 | 12 | Maser | −171 |
| 157 | 51 | 020 | −159.3 | −161.1 | 12 | Maser | −171 |
| 158 | 11 | 021/2 | −159.4 | −160 7 | 12 | Maser | −171 |
| 159 | 51 | 022 | −159.5 | −161.5 | 12 | Maser | −171 |
| 160 | 42 | 023 | −159.6 | −159.9 | 12 | Maser | −172 |
| 160 | 11 | 023/4 | −159 6 | −160.4 | 12 | Maser | — |
| 161 | 42 | 024 | −159 6 | −160.0 | 12 | Maser | −172 |
| 161 | 62 | 024/5 | −159 6 | −160.8 | 12 | Maser | −173 |
| 161 | 12 | 024/5 | −159.6 | −160.7 | 12 | Maser | −173 |
| 162 | 51 | 025 | −159.7 | −161.8 | 12 | Maser | −171 |
| 163 | 62 | 025/6 | −159.7 | −161.4 | 12 | Maser | −174 |
| 163 | 42 | 026 | −159.7 | −161.2 | 12 | Maser | −172 |
| 163 | 12 | 026 | −159.7 | −160.9 | 12 | Maser | — |
| 164 | 62 | 027/8 | −159.9 | −161.2 | 12 | Maser | −174 |
| 164 | 11 | 027/8 | −159.9 | −161.5 | 12 | Maser | −171 |
| 166 | 51 | 029 | −160.2 | −162.1 | 12 | Maser | −172 |
| 167 | 51 | 030 | −160.3 | −161.8 | 12 | Maser | −171 |
| 167 | 12 | 030/1 | −160.3 | −161.4 | 12 | Maser | −172 |
| 168 | 42 | 031 | −160.5 | −161.0 | 12 | Maser | −172 |
| 169 | 42 | 032 | −160 6 | −161.5 | 12 | Maser | −172 |
| 170 | 11 | 032 | −160.7 | −163.0 | 12 | Maser | −172 |
| 170 | 42 | 033 | −160.7 | −161.5 | 12 | Maser | −172 |
| 170 | 51 | 033 | −160.7 | −161.9 | 12 | Maser | −171 |
| 171 | 11 | 034 | −160 9 | −162.3 | 12 | Maser | −171 |

Table 41 (contd)

| Pass | Station | Day | Predicted signal strength, dBmW | Average receiver signal strength, dBmW | Configuration | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tracking loop bandwidth, HZ | Maser or paramplifier configuration | Threshold, dBmW |
| 171 | 42 | 034 | −160.9 | −161.8 | 12 | Maser | −171 |
| 174 | 42 | 037 | −161.4 | −162.0 | 12 | Maser | −172 |
| 174 | 51 | 037 | −161.4 | −162 0 | 12 | Maser | −170 |
| 174 | 11 | 038 | −161.4 | −162.1 | 12 | Maser | −171 |
| 175 | 42 | 038 | −161.5 | −162.5 | 12 | Maser | −173 |
| 175 | 51 | 038 | −161.5 | −162 4 | 12 | Maser | −170 |
| 176 | 42 | 039 | −161.6 | −162 0 | 12 | Maser | −173 |
| 176 | 11 | 040 | −161.6 | −162.0 | 12 | Maser | −171 |
| 177 | 42 | 040 | −161.6 | −163.5 | 12 | Maser | −172 |
| 177 | 51 | 040 | −161.7 | −162.3 | 12 | Maser | −170 |
| 178 | 42 | 041 | −161.7 | −163.5 | 12 | Maser | −172 |
| 178 | 51 | 041 | −161 8 | −162 3 | 12 | Maser | −170 |
| 179 | 42 | 042 | −161.8 | −163.0 | 12 | Maser | −172 |
| 180 | 42 | 043 | −161.9 | −162.5 | 12 | Maser | −172 |
| 180 | 11 | 043/4 | −161.9 | −162.1 | 12 | Maser | −172 |
| 181 | 51 | 044 | −161.9 | −162.5 | 12 | Maser | −171 |
| 181 | 11 | 044/5 | −162.0 | −161.7 | 12 | Maser | — |
| 182 | 42 | 045 | −162.0 | −162.5 | 12 | Maser | −172 |
| 182 | 51 | 045 | −162.0 | −162.5 | 12 | Maser | −170 |
| 182 | 11 | 045/6 | −162.0 | −162.8 | 12 | Maser | −171 |
| 183 | 42 | 046 | −162.1 | −163.0 | 12 | Maser | −173 |
| 183 | 51 | 046 | −162.1 | −163.0 | 12 | Maser | −171 |
| 184 | 42 | 047 | −162.2 | −163.0 | 12 | Maser | −173 |
| 184 | 51 | 047 | −162.2 | −163.3 | 12 | Maser | −171 |
| 185 | 42 | 048 | −162.2 | −162.5 | 12 | Maser | −173 |
| 185 | 51 | 048 | −162.3 | −163.3 | 12 | Maser | −169 |
| 186 | 42 | 049 | −162.3 | −162.5 | 12 | Maser | −172 |
| 186 | 51 | 049 | −162.4 | −164 0 | 12 | Maser | −171 |
| 187 | 42 | 050 | −162.4 | −162.5 | 12 | Maser | −174 |
| 188 | 42 | 051 | −162.5 | −163.0 | 12 | Maser | −173 |
| 189 | 42 | 052 | −162.6 | −162.0 | 12 | Maser | −172 |
| 189 | 51 | 052 | −162 6 | −163 0 | 12 | Maser | −171 |
| 189 | 14 | 052/3 | −152.6 | −154.6 | 12 | Maser | −175 |
| 190 | 42 | 053 | −162.7 | −163.4 | 12 | Maser | −172 |
| 190 | 51 | 053 | −162.8 | −163.5 | 12 | Maser | −171 |
| 191 | 42 | 053/4 | −162.8 | −163.5 | 12 | Maser | −172 |

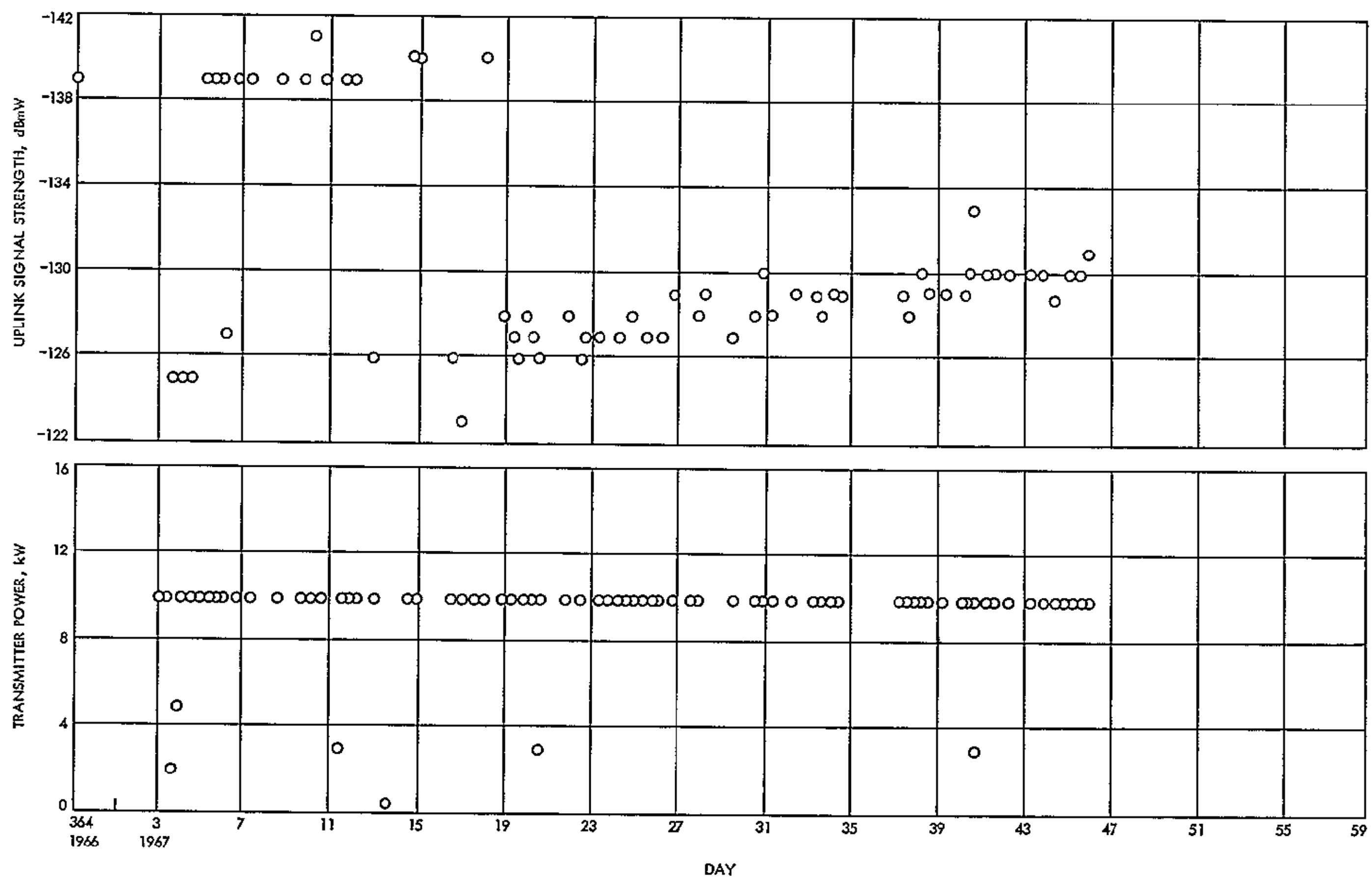


**Fig. 69. Uplink signal strength and transmitter power vs time**

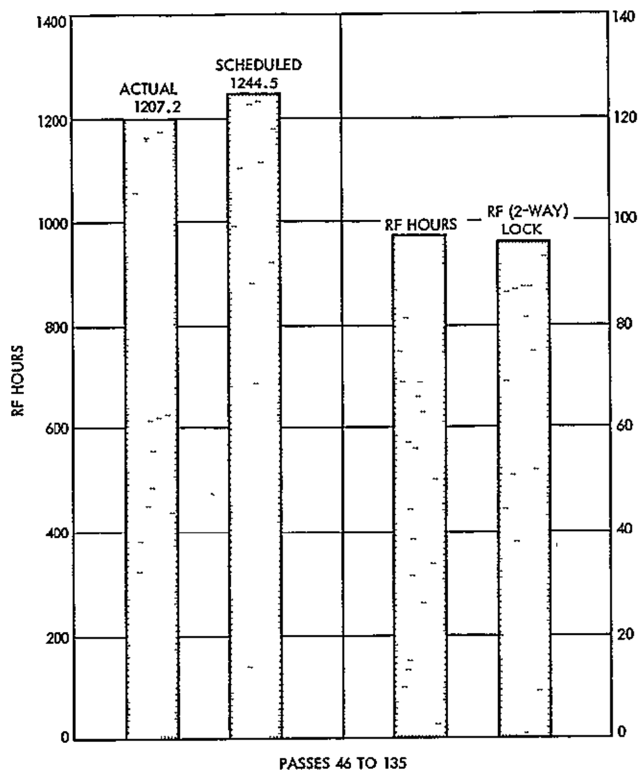


Fig. 70. Percent in lock vs actual scheduled (passes 46–135)

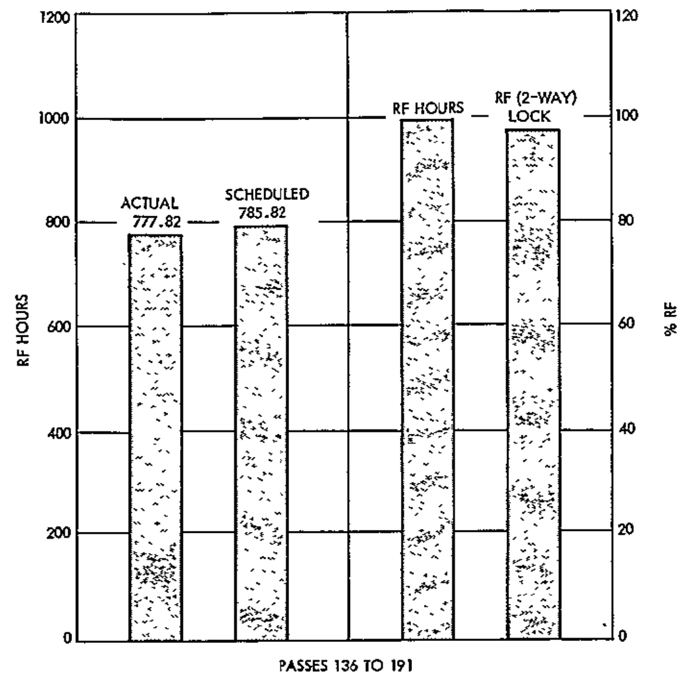


Fig. 71. Percent in lock vs actual scheduled (passes 36–191)

Table 42. Bit error rate

| Pass | DSS | Day | Average bit error rate computed from engineering printout | Average signal strength, dBmW | Bit rate, bits/s | Pass | DSS | Day | Average bit error rate computed from engineering printout | Average signal bits/s dBmW | Bit rate, bits/s |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 42 | 274 | 0.000 | −143.0 | 512 | 52 | 51 | 280/1 | 0.000 | −144.3 | 512 |
| 46 | 51 | 274/5 | 0.000 | −142.8 | 512 | 53 | 12 | 282 | — | −143.8 | 512 |
| 46 | 12 | 275 | 0.000 | −142.8 | 512 | 54 | 12 | 283 | — | −144.7 | 512 |
| 47 | 42 | 275 | 0.000 | −143.1 | 512 | 56 | 12 | 285 | 0.004 | −144.9 | 512 |
| 47 | 51 | 275/6 | 0.000 | −142.4 | 512 | 58 | 12 | 287 | 0.008 | −145.4 | 512 |
| 48 | 42 | 276 | 0.000 | −143.5 | 512 | 59 | 51 | 287/8 | 0.010 | −145.6 | 512 |
| 48 | 12 | 277 | 0.000 | −143.1 | 512 | 60 | 12 | 289 | — | −146.0 | 512 |
| 49 | 42 | 277 | 0 000 | −143.1 | 512 | 61 | 41 | 289 | — | −146.0 | 512 |
| 49 | 12 | 278 | 0.000 | −143.2 | 512 | 61 | 51 | 289/0 | 0.017 | −146.0 | 512 |
| 50 | 12 | 279 | 0.000 | −143.2 | 512 | 63 | 12 | 292 | 0.055 | −148.8 | 512 |
| 51 | 51 | 279/0 | 0.000 | −143.3 | 512 | 65 | 12 | 294 | 0 075 | −147.1 | 512 |
| 51 | 12 | 280 | 0.000 | −143.9 | 512 | 66 | 12 | 295 | 0.048 | −147.1 | 512 |
| 52 | 42 | 280 | 0 000 | −144.0 | 512 | 68 | 12 | 296/7 | 0.023 | −148.4 | 256 |

## Table 42 (contd)

| Pass | DSS | Day | Average bit error rate computed from engineering printout | Average signal strength, dBmW | Bit rate, bits/s |
|---|---|---|---|---|---|
| 70 | 12 | 298/9 | 0.033 | −148.0 | 256 |
| 72 | 51 | 300 | 0.005 | −149.0 | 256 |
| 74 | 12 | 302/3 | 0 032 | −149.0 | 256 |
| 76 | 12 | 304/5 | 0.023 | −147.0 | 256 |
| 78 | 12 | 306/7 | 0.025 | −148.0 | 256 |
| 80 | 51 | 308/9 | 0.010 | −149.6 | 256 |
| 80 | 11 | 308/9 | 0.060 | −150.1 | 256 |
| 82 | 51 | 310 | 0.002 | −151.1 | 64 |
| 85 | 11 | 313/4 | 0.010 | −146.0 | 64 |
| 86 | 51 | 314/5 | 0.001 | −151.3 | 64 |
| 86 | 11 | 314/5 | 0.000 | −151.6 | 64 |
| 87 | 51 | 315 | 0.002 | −152.0 | 64 |
| 87 | 11 | 316 | 0.004 | −151.0 | 64 |
| 90 | 51 | 318/9 | 0.009 | −151.2 | 64 |
| 91 | 51 | 319/0 | 0.007 | −152.0 | 64 |
| 92 | 51 | 320/1 | 0.016 | −152 0 | 64 |
| 93 | 51 | 321/2 | 0.010 | −153.1 | 64 |
| 93 | 11 | 322 | 0.001 | −154.5 | 64 |
| 94 | 51 | 322 | 0.015 | −153.1 | 64 |
| 94 | 11 | 323 | 0.004 | −153.0 | 64 |
| 96 | 51 | 324/5 | 0.045 | −152.7 | 64 |
| 97 | 51 | 325 | 0.035 | −153.2 | 64 |
| 98 | 51 | 326 | 0.016 | −153.1 | 64 |
| 98 | 11 | 326/7 | 0.020 | −153.0 | 64 |
| 99 | 51 | 327 | 0.010 | −153.8 | 64 |
| 99 | 11 | 327/8 | 0.002 | −151.5 | 64 |
| 101 | 51 | 329 | 0.020 | −153.6 | 64 |
| 103 | 14 | 332 | 0.000 | −143.6 | 512 |
| 105 | 51 | 333 | 0.015 | −155.0 | 64 |
| 106 | 51 | 334 | 0.035 | −154.6 | 64 |
| 107 | 51 | 335 | 0.060 | −155.6 | 64 |
| 107 | 11 | 335/6 | 0.004 | −155.0 | 64 |
| 108 | 51 | 336 | 0.022 | −155 0 | 64 |
| 108 | 11 | 336/7 | 0.015 | −153 0 | 64 |
| 111 | 51 | 339 | 0.020 | −155.0 | 64 |
| 112 | 51 | 340 | 0.028 | −155.1 | 64 |
| 113 | 51 | 341 | 0.045 | −156.5 | 64 |
| 114 | 51 | 342 | 0.030 | −155.5 | 64 |
| 114 | 11 | 343 | 0.035 | −154.4 | 64 |
| 115 | 51 | 343 | 0.060 | −155.5 | 64 |
| 115 | 11 | 344 | 0.070 | −156.5 | 64 |
| 116 | 51 | 344 | 0.065 | −155.7 | 64 |
| 117 | 51 | 345 | 0.150 | −156.0 | 64 |
| 117 | 11 | 345/6 | — | −156.3 | 64 |
| 118 | 51 | 346 | 0.250 | −158 3 | 16 |
| 119 | 51 | 347 | 0.015 | −156.1 | 16 |
| 120 | 51 | 348 | 0.005 | −156.5 | 16 |
| 120 | 12 | 348/9 | 0.065 | −156.7 | 64 |
| 121 | 51 | 349 | 0.000 | −156.6 | 16 |
| 121 | 12 | 349/0 | 0.050 | −156.7 | 16 |
| 122 | 51 | 250 | 0.005 | −156 3 | 16 |
| 124 | 51 | 352 | 0.000 | −156.6 | 16 |
| 125 | 51 | 353 | 0.005 | −157.4 | 16 |
| 125 | 12 | 354 | 0.020 | −157.7 | 16 |
| 126 | 51 | 354 | 0.000 | −157.8 | 16 |
| 126 | 12 | 354/5 | 0.000 | −157.4 | 16 |
| 127 | 51 | 355 | 0.000 | −157.5 | 16 |
| 127 | 12 | 355/6 | 0.015 | −158.0 | 16 |
| 128 | 51 | 356 | 0.010 | −157.4 | 16 |
| 133 | 51 | 361 | 0.006 | −157.6 | 16 |
| 133 | 12 | 361/2 | — | −160.0 | 16 |
| 134 | 51 | 362 | 0.010 | −158.5 | 16 |
| 135 | 12 | 363/4 | 0.005 | −158.3 | 16 |
| 135 | 51 | 363 | 0.002 | −158.6 | 16 |
| 136 | 51 | 364 | 0.010 | −159.1 | 16 |
| 140 | 51 | 003 | 0.010 | −160.0 | 16 |
| 140 | 14 | 003/4 | 0.020 | −149.0 | 256 |
| 141 | 42 | 004 | N/A | −157.3 | 16 |
| 141 | 51 | 004 | 0.010 | −158.8 | 16 |
| 141 | 12 | 004/5 | 0.000 | −158.7 | 16 |
| 142 | 42 | 005 | N/A | −158.6 | 16 |
| 142 | 51 | 005 | 0.025 | −159.0 | 16 |
| 142 | 12 | 005 | 0.025 | −158.8 | 16 |

## Table 42 (contd)

| Pass | DSS | Day | Average bit error rate computed from engineering printout | Average signal strength, dBmW | Bit rate, bits/s |
|---|---|---|---|---|---|
| 143[a] | 51 | 006 | 0.050 | −159.4 | 16 |
| 143 | 12 | 007 | 0.020 | −158.7 | 16 |
| 145 | 51 | 008 | 0.020 | −159.4 | 16 |
| 146 | 51 | 009 | 0.020 | −160.6 | 16 |
| 146[a] | 11 | 009/0 | 0.060 | −159.1 | 16 |
| 147 | 51 | 010 | 0.020 | −160.7 | 16 |
| 148 | 41 | 011 | N/A | −159.5 | 16 |
| 148 | 51 | 011 | 0.035 | −161.0 | 16 |
| 148 | 11 | 011/2 | 0.120 | −159.5 | 16 |
| 149 | 11 | 012/3 | 0.005 | −158.6 | 16 |
| 151 | 51 | 014 | 0.040 | −160.4 | 16 |
| 151 | 11 | 014/5 | 0.075 | −161.3 | 16 |
| 153 | 51 | 016 | 0.035 | −160.2 | 16 |
| 153 | 14 | 016/7 | 0.150 | −150.3 | 256 |
| 154 | 62 | 017 | N/A | −165.6 | 16 |
| 154 | 12 | 017/8 | 0.010 | −159.6 | 16 |
| 155 | 12 | 018/9 | 0.005 | −161.0 | 16 |
| 156 | 42 | 019 | 0.045 | −160.2 | 16 |
| 156 | 12 | 019/0 | 0.020 | −161.5 | 16 |
| 157 | 42 | 020 | 0.080 | −161.5 | 16 |
| 157 | 41 | 020 | N/A | −159.0 | 16 |
| 157 | 51 | 020 | 0.185 | −161.1 | 16 |
| 158 | 11 | 021/2 | 0.150 | −160.7 | 16 |
| 159 | 51 | 022 | 0.055 | −161.5 | 16 |
| 160 | 42 | 023 | 0.030 | −159.9 | 16 |
| 160 | 11 | 023/4 | 0.005 | −160.4 | 16 |
| 161 | 42 | 024 | 0.030 | −160.0 | 16 |
| 161 | 62 | 024/5 | N/A | −160.8 | 16 |
| 161 | 12 | 024/5 | 0.010 | −160.7 | 16 |
| 162 | 51 | 025 | 0.250 | −161.8 | 16 |
| 163 | 62 | 025/6 | N/A | −161.4 | 16 |
| 163 | 42 | 026 | 0.085 | −161.2 | 16 |
| 163 | 12 | 026 | 0.000 | −160.9 | 16 |
| 164 | 62 | 027/8 | N/A | −161.2 | 16 |
| 164 | 11 | 027/8 | 0.450 | −161.5 | 16 |
| 166 | 51 | 029 | 0.200 | −162.1 | 64 |
| 167 | 51 | 030 | 0.215 | −161.8 | 64 |
| 167 | 12 | 030/1 | 0.055 | −161.4 | 16 |
| 168 | 42 | 031 | 0.030 | −161.0 | 16 |
| 169 | 42 | 032 | 0.240 | −161.5 | 16 |
| 170 | 11 | 032 | 0.040 | −163.0 | 8 |
| 170 | 42 | 033 | 0.225 | −161.5 | 16 |
| 170 | 51 | 033 | 0.070 | −161.9 | 16 |
| 171 | 11 | 034 | 0.035 | −162.3 | 8 |
| 171 | 42 | 034 | 0.120 | −161.8 | 8 |
| 174 | 42 | 037 | 0.040 | −162.0 | 8 |
| 174 | 51 | 037 | 0.135 | −162.0 | 8 |
| 174 | 11 | 038 | 0.030 | −162.1 | 8 |
| 175 | 42 | 038 | 0.025 | −162.5 | 8 |
| 175 | 51 | 038 | 0.060 | −162.4 | 8 |
| 176 | 42 | 039 | 0.030 | −162.0 | 8 |
| 176 | 11 | 040 | 0.070 | −162.0 | 8 |
| 177 | 42 | 040 | 0.140 | −163.5 | 8 |
| 177 | 51 | 040 | 0.125 | −162.3 | 8 |
| 178 | 42 | 041 | 0.160 | −163.5 | 8 |
| 178 | 51 | 041 | 0.095 | −162.3 | 8 |
| 179 | 42 | 042 | 0.200 | −163.0 | 8 |
| 180 | 42 | 043 | 0.190 | −162.5 | 8 |
| 180 | 11 | 043/4 | 0.035 | −162.1 | 8 |
| 181 | 51 | 044 | 0.085 | −162.5 | 8 |
| 181 | 11 | 044/5 | 0.030 | −161.7 | 8 |
| 182 | 42 | 045 | 0.045 | −162.5 | 8 |
| 182 | 51 | 045 | 0.130 | −162.5 | 8 |
| 182 | 11 | 045/6 | 0.075 | −162.8 | 8 |
| 183 | 42 | 046 | 0.085 | −163.0 | 8 |
| 183 | 51 | 046 | 0.160 | −163.0 | 8 |
| 184 | 42 | 047 | 0.200 | −163.0 | 8 |
| 184 | 51 | 047 | 0.125 | −163.0 | 8 |

[a]Abnormally high error rate while receiver AGC was constant.

Table 42 (contd)

| Pass | DSS | Day | Average bit error rate computed from engineering printout | Average signal strength, dBmW | Bit rate, bits/s |
|---|---|---|---|---|---|
| 185 | 42 | 048 | 0.109 | −162.5 | 8 |
| 185 | 51 | 048 | 0.250 | −163.3 | 8 |
| 186 | 42 | 049 | 0.080 | −162.5 | 8 |
| 186 | 51 | 049 | 0.220 | −164.0 | 8 |
| 187 | 42 | 050 | 0.085 | −162.5 | 8 |
| 188 | 42 | 051 | 0.110 | −163.0 | 8 |
| 189 | 42 | 052 | 0.150 | −162.0 | 8 |
| 189 | 51 | 052 | 0.330 | −163 0 | 8 |
| 189 | 14 | 052/3 | 0.010 | −154.6 | 64 |
| 190 | 42 | 053 | 0.109 | −163 4 | 16 |
| 190 | 51 | 053 | 0.500 | −163.5 | 8 |
| 191 | 42 | 053/4 | 0.250 | −163.5 | 16 |

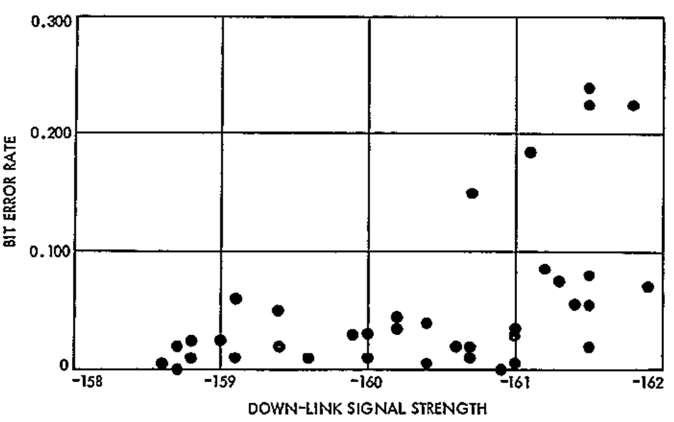


**Fig. 72. Bit error rate vs downlink signal strength (16 bits/s)**

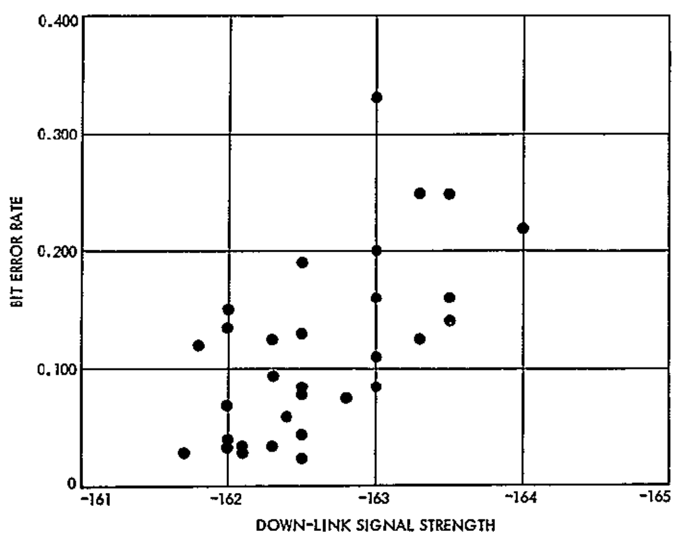


**Fig. 73. Bit error rate vs downlink signal strength (8 bits/s)**

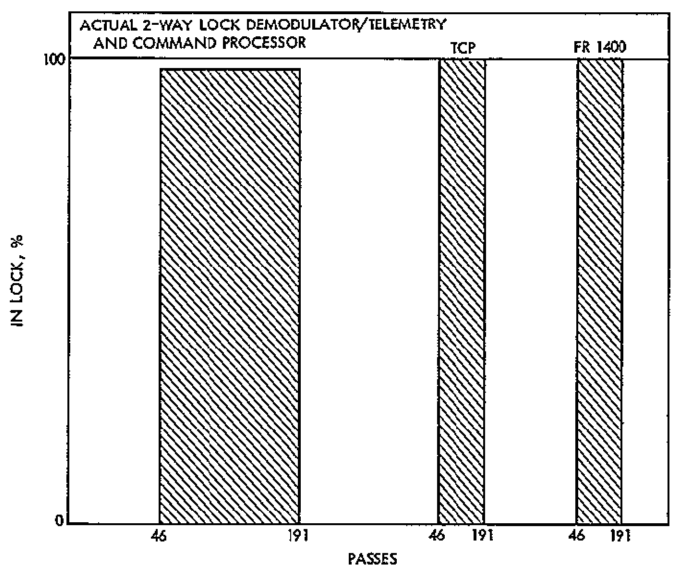


**Fig. 74. Percent demodulator/TCP in lock**

## Table 43. Predicted vs actual telemetry bit rate changes for 85-ft antennas (December 1966–January 1967)

| Predicted* | | | | | Actual | | |
|---|---|---|---|---|---|---|---|
| Time from launch, days (desired) | Time from launch, days (forecast) | Desired range, km × $10^6$ | Forecast range, km × $10^6$ | Expected bit rate, bits/s | Time from launch, days | Range, km × $10^6$ | Bit rate, bits/s |
| 69 | | 9.1255 | | 512 | 67 (10/24/66) | 11.7790 | 512 |
| 84 | | 13.463865 | | 256 | 80 (11/6/66) | 15.7888 | 256 |
| 114 | 112 (12/8/66) | 27.07733 | 28.72189 | 64 | 114 (12/11/66) | 29.5 | 64 |
| 130 | 135 (1/30/67) | 39.04520 | 57.0 | 16[a] | 173 2-3-67 | 58.3157 | 16[a] |
| 222 | 204 (4/25/67) | 94.00 | 94.00 | 8 | | | |

[a]Calculation of telemetry margin threshold for 16 bits/s:

(1) Present space loss $(SL)_2 = 104 + 20 \log (28.72189 \times 10^6 \times 0.62)$
$= 104 + 20 \log (178.075 \times 10^5)$
$= 104 + 20\ (5.2504)$
$= 209$ dBmW

(2) Forecasted space loss $(SL)_1 = 37 + 67 + 20 \log \text{range}$
$= 104 + 20 \log (58.3157 \times 10^6 \times 0.62)$
$= 104 + 20 \log (361.55734 \times 10^5)$
$= 104 + 20\ (5.558)$
$= 215.2$ dBmW

(3) $SL_1 - SL_2 \cong 6.2$ dBmW threshold margin for 16 bits/s.

(4) Present signal, November 29, 1966 = −155 dBmW.

(5) Predicted threshold for 16 bits/s = −161.2 dBmW around January 30, 1967.

(6) Actual threshold for 16 bits/s = −161.5 dBmW on February 3, 1967 (pass 171).

## Table 44. Command history

| Pass | Station | Day | Commands transmitted | Command total | Pass | Station | Day | Commands transmitted | Command total |
|---|---|---|---|---|---|---|---|---|---|
| 46 | 42 | 274 | 13 | 1582 | 53 | 12 | 282 | 21 | 1768 |
| | 51 | 274/275 | 6 | 1590 | 54 | 12 | 283 | 18 | 1786 |
| | 12 | 275 | 18 | 1608 | 56 | 12 | 285 | 21 | 1807 |
| 47 | 42 | 275 | 4 | 1612 | 58 | 12 | 287 | 15 | 1822 |
| | 51 | 275/276 | 7 | 1619 | 59 | 51 | 287 | 15 | 1837 |
| 48 | 42 | 276 | 21 | 1640 | 60 | 12 | 289 | 14 | 1851 |
| 48 | 12 | 277 | 13 | 1653 | 61 | 41 | 289 | | |
| 49 | 42 | 277 | 9 | 1662 | 61 | 51 | 289 | 9 | 1860 |
| | 12 | 278 | 20 | 1688 | 63 | 12 | 292 | 21 | 1881 |
| 50 | 12 | 279 | 20 | 1708 | 65 | 12 | 294 | 24 | 1905 |
| 51 | 51 | 279/280 | 9 | 1717 | 66 | 12 | 295 | 19 | 1924 |
| | 12 | 280 | 8 | 1725 | 68 | 12 | 296/297 | 25 | 1949 |
| 52 | 42 | 280 | 13 | 1738 | 70 | 12 | 298/299 | 23 | 1972 |
| | 51 | 280 | 9 | 1747 | 72 | 51 | 300 | 15 | 1987 |

Table 44 (contd)

| Pass | Station | Day | Commands transmitted | Command total |
|---|---|---|---|---|
| 74 | 12 | 303 | 18 | 2005 |
| 76 | 12 | 304 | 23 | 2028 |
| 78 | 12 | 306/307 | 15 | 2043 |
| 80 | 51 | 308/309 | 19 | 2062 |
| 80 | 11 | 308/309 | 19 | 2081 |
| 82 | 51 | 310 | 8 | 2089 |
| 85 | 11 | 313/314 | 17 | 2106 |
| | 51 | 313/314 | 12 | 2118 |
| 86 | 11 | 314/315 | 18 | 2136 |
| | 51 | 314/315 | 9 | 2145 |
| 87 | 51 | 315 | 11 | 2167 |
| | 11 | 316 | 11 | 2156 |
| 90 | 51 | 318/9 | 15 | 2182 |
| 90 | 51 | 319/320 | 15 | 2197 |
| 92 | 51 | 320 | 15 | 2212 |
| 93 | 51 | 321/322 | 14 | 2226 |
| | 11 | 322 | 15 | 2241 |
| 94 | 51 | 322 | 8 | 2249 |
| | 11 | 323 | 9 | 2258 |
| 96 | 51 | 324 | 13 | 2271 |
| 97 | 51 | 325 | 15 | 2286 |
| 98 | 51 | 326 | 13 | 2299 |
| | 11 | 326/327 | 13 | 2312 |
| 99 | 51 | 327 | 12 | 2324 |
| | 11 | 327/328 | 17 | 2341 |
| 101 | 51 | 329 | 15 | 2366 |
| 103 | 14 | 332 | 17 | 2383 |
| 105 | 51 | 333 | 10 | 2393 |
| 106 | 51 | 334 | 14 | 2407 |
| 107 | 51 | 335 | 9 | 2416 |
| | 11 | 335 | 7 | 2423 |
| 108 | 51 | 336 | 9 | 2432 |
| | 11 | 337 | 16 | 2448 |
| 111 | 51 | 339 | 13 | 2461 |
| 112 | 51 | 340 | 12 | 2473 |
| 113 | 51 | 341 | 15 | 2488 |
| 114 | 51 | 342 | 14 | 2502 |
| | 11 | 343 | 15 | 2517 |
| 115 | 51 | 343 | 9 | 2526 |
| | 11 | 344 | 12 | 2538 |
| 116 | 51 | 344 | 15 | 2553 |

| Pass | Station | Day | Commands transmitted | Command total |
|---|---|---|---|---|
| 117 | 51 | 345 | 11 | 2564 |
| | 11 | 345/346 | 12 | 2576 |
| 118 | 51 | 346 | 13 | 2589 |
| 119 | 51 | 347 | 33 | 2622 |
| 120 | 51 | 348 | 15 | 2637 |
| | 12 | 348/349 | 26 | 2663 |
| 121 | 51 | 349 | 14 | 2677 |
| | 12 | 349/340 | 26 | 2703 |
| 122 | 51 | 350 | 18 | 2721 |
| 124 | 51 | 352 | 18 | 2739 |
| 125 | 12 | 354 | 26 | 2765 |
| 125 | 51 | 353 | 20 | 2785 |
| 126 | 51 | 354 | 16 | 2801 |
| | 12 | 354 | 17 | 2818 |
| 127 | 51 | 355 | 12 | 2830 |
| | 12 | 356 | 18 | 2848 |
| 128 | 51 | 356 | 15 | 2863 |
| 133 | 51 | 361 | 13 | 2876 |
| | 12 | 361 | 4 | 2880 |
| 134 | 51 | 362 | 13 | 2268 |
| 135 | 12 | 363/364 | 16 | 2284 |
| 136 | 51 | 364 | 11 | 2295 |
| 140 | 51 | 003 | 9 | 2334 |
| 140 | 14 | 003/004 | 30 | 2325 |
| 141 | 42 | 004[a] | 0 | 2325 |
| | 51 | 004 | 7 | 2341 |
| | 12 | 004 | 11 | 2352 |
| 142 | 42 | 005[a] | 0 | 2352 |
| | 51 | | 15 | 2367 |
| | 12 | | 3 | 2370 |
| 143 | 51 | 006 | 8 | 2378 |
| 143 | 12 | 007 | 22 | 2400 |
| 145 | 51 | 008 | 28 | 2428 |
| 146 | 51 | 009 | 8 | 2436 |
| 146 | 11 | 009 | 17 | 2453 |
| 147 | 51 | 010 | 12 | 2465 |
| 148 | 41 | 011 | 0 | 2489 |
| 148 | 51 | 011 | 5 | 2470 |
| 148 | 11 | 011/012 | 19 | 2489 |
| 149 | 11 | 012/013 | 16 | 2505 |
| 151 | 51 | 014 | 22 | 2527 |

## Table 44 (contd)

| Pass | Station | Day | Commands transmitted | Command total |
|---|---|---|---|---|
| 151 | 11 | 014/015 | 15 | 2542 |
| 153 | 51 | 016 | 19 | 2561 |
| 153 | 14 | 016/017 | 57 | 2618 |
| 154 | 62 | 017/018 | 0 | 2618 |
| 154 | 12 | 017/018 | 18 | 2636 |
| 155 | 12 | 018/019 | 13 | 2648 |
| 156 | 42 | 019 | 10 | 2658 |
| 156 | 12 | 019/020 | 22 | 2680 |
| 157 | 41 | 020 | 0 | 2702 |
| 157 | 51 | 020 | 5 | 2707 |
| 158 | 11 | 021/022 | 27 | 2734 |
| 159 | 51 | 022 | 8 | 2742 |
| 160 | 42 | 023 | 10 | 2752 |
| 160 | 11 | 023/024 | 0 | 2752 |
| 161 | 42 | 024 | 11 | 2763 |
| 161 | 62 | 024/025 | 0 | 2763 |
| 161 | 12 | 024/025 | 15 | 2778 |
| 162 | 51 | 025 | 8 | 2786 |
| 163 | 62 | 025/026 | 0 | 2786 |
| 163 | 42 | 026 | 12 | 2798 |
| 163 | 12 | 026 | 1 | 2799 |
| 164 | 62 | 027/028 | 0 | 2799 |
| 164 | 11 | 027/028 | 14 | 2813 |
| 166 | 51 | 029 | 25 | 2838 |
| 167 | 51 | 030 | 22 | 2860 |
| 167 | 12 | 030/031 | 23 | 2883 |
| 168 | 42 | 031 | 17 | 2900 |
| 169 | 42 | 032 | 21 | 2921 |
| 170 | 42 | 033 | 20 | 2941 |
| | 51 | 033 | 28 | 2969 |
| | 11 | 034 | 16 | 2985 |
| 171 | 42 | 034 | 20 | 3005 |
| | 11 | 035 | 21 | 3026 |
| 174 | 42 | 037 | 22 | 3048 |
| | 51 | 037 | 26 | 3074 |
| | 11 | 038 | 15 | 3089 |
| 175 | 42 | 038 | 9 | 3098 |
| | 51 | 038 | 24 | 3122 |
| 176 | 42 | 039 | 24 | 3146 |
| | 11 | 040 | 13 | 3159 |
| 177 | 42 | 040 | 13 | 3172 |
| | 51 | 040 | 15 | 3187 |
| 178 | 42 | 041 | 20 | 3207 |
| | 51 | 041 | 23 | 3230 |
| 179 | 42 | 042 | 26 | 3256 |
| 180 | 42 | 043 | 26 | 3282 |
| | 11 | 043/044 | 39 | 3321 |
| 181 | 51 | 044 | 27 | 3348 |
| | 11 | 044/045 | 16 | 3364 |
| 182 | 42 | 045 | 25 | 3389 |
| | 51 | 045 | 35 | 3424 |
| | 11 | 045/046 | 38 | 3462 |
| 183 | 42 | 046 | 7 | 3469 |
| | 51 | 046 | 27 | 3496 |
| 184 | 42 | 047 | 29 | 3525 |
| | 51 | 047 | 36 | 3561 |
| 185 | 42 | 048 | 22 | 3583 |
| | 51 | 048 | 18 | 3601 |
| 186 | 42 | 049 | 17 | 3618 |
| | 51 | | 26 | 3644 |
| 187 | 42 | 050 | 21 | 3665 |
| 188 | 42 | 051 | 20 | 3685 |
| 189 | 42 | 052 | 15 | 3700 |
| 189 | 51 | 052 | 21 | 3721 |
| 189 | 14 | 052 | 6 | 3727 |
| 190 | 42 | 053 | 11 | 3738 |
| 191 | 42 | 054 | 17 | 3777 |

[a]GOE reinstallation.

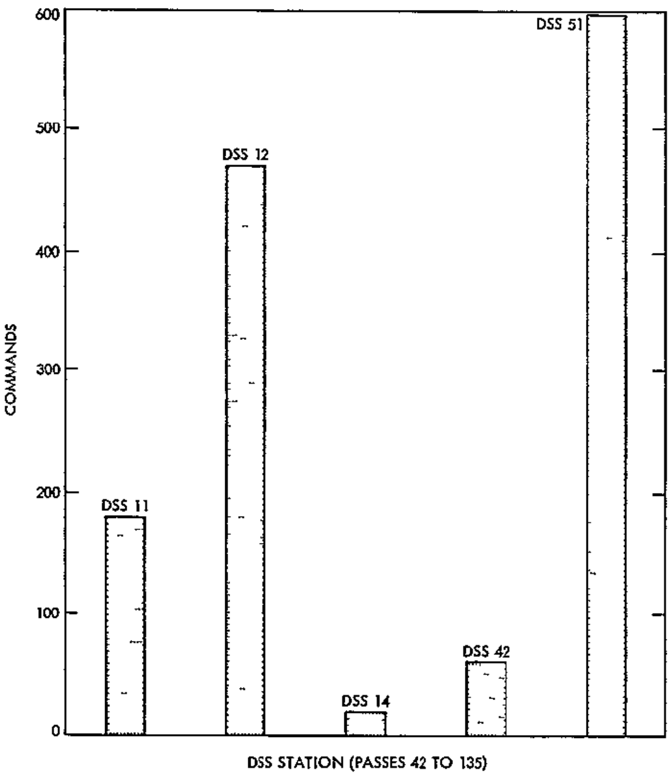


**Fig. 75. Total commands by station (passes 42–135)**

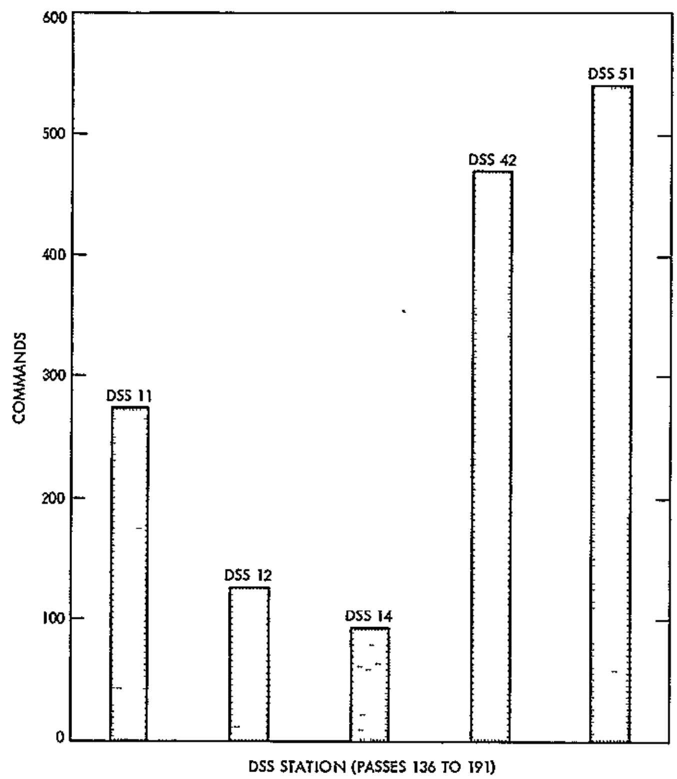


**Fig. 76. Total commands by station (passes 136–191)**

(5) Predictions:

(a) Sets generated:

Stations.

Frequencies used.

Coverage/rates used (Table 45).

(6) Predicted frequency performance:

(a) Auxiliary oscillator vs predicted (Fig. 77).

(b) Best lock vs predicted.

The parameters monitored in non-real-time are as follows:

(1) Station tracking time and mode configuration.

(2) Pre- and post-signal-to-noise ratio.

(3) Command performance.

(4) "On-off" events such as the transmitter receiver, bit rate mode changes, and power level changes.

(5) Demodulator and TCP in-lock percentage.

(6) Two-way RF in- and out-of-lock times in percentages.

(7) Average receiver AGC, average bit error rate, and average up-link power readings.

(8) Tracking data/doppler mode, VCO frequency, and angle performance.

(9) Tracking frequencies, tuning rates, lock-times, and drop lock times for spacecraft acquisition.

Most of these parameters are stored on computer cards for further statistical computation.

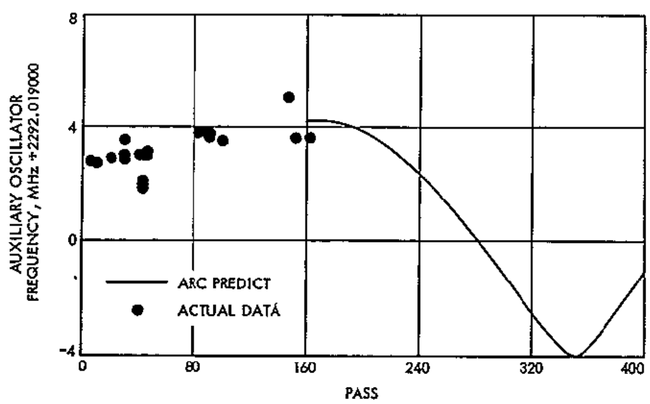


**Fig. 77. Auxiliary oscillator frequency vs pass number**

## Table 45. Deep Space Station Predicts

| Predict | Stations | Spacecraft RF frequency, MHz | Transmitter reference, MHz | Coverage | Sample rate, s |
|---|---|---|---|---|---|
| 33Y | 11, 42, 51 | 2292.018850 | 21.988905 | 8/20/66– 8/21/66 | 600 |
| 34X | 11, 42, 51 | 2292.018850 | 21.985268 | 8/20/66– 9/05/66 | 900 |
| 34X | Stanford | 2292.018850 | 21.985268 | 8/20/66– 9/12/66 | 300 |
| 34Y | 11, 42, 51 | 2292.018850 | 21.988905 | 8/20/66– 9/05/66 | 900 |
| 35X | 11, 41, 42, 51, 61 | 2292.018850 | 21.985268 | 8/24/66– 9/08/66 | 900 |
| 35X | Stanford | 2292.018850 | 21.985268 | 8/24/66– 9/08/66 | 300 |
| 35Y | 11, 41, 42, 51, 61 | 2292.018850 | 21.988905 | 8/24/66– 9/08/66 | 900 |
| 36X | 11, 41, 42, 51, 61 | 2292.018850 | 21.985268 | 9/07/66– 9/22/66 | 900 |
| 36X | Stanford | 2292.018850 | 21.985268 | 9/17/66– 9/22/66 | 300 |
| 36Y | 11, 41, 42, 51, 61 | 2292.018850 | 21.988905 | 9/07/66– 9/22/66 | 900 |
| 37X | 11, 41, 42, 51, 61 | 2292.016000 | 21.985260 | 9/21/66–10/06/66 | 900 |
| 37X | Stanford | 2292.016000 | 21.985260 | 9/21/66–10/06/66 | 300 |
| 37Y | 11, 41, 42, 51, 61 | 2292.016000 | 21.988905 | 9/21/66–10/06/66 | 900 |
| 37Z | 14 | 2292.016000 | 21.985270 | 9/17/66–10/02/66 | 300 |
| 38X | 11, 14, 42, 51, 61 | 2292.016000 | 21.985270 | 10/05/66–10/20/66 | 900 |
| 38X | Stanford | 2292.016000 | 21.985270 | 10/05/66–10/20/66 | 300 |
| 38Y | 11, 41, 42, 51, 61 | 2292.016000 | 21.988905 | 10/05/66–10/20/66 | 900 |
| 39X | 11, 41, 42, 51, 61 | 2292.016000 | 21.985270 | 10/19/66–11/03/66 | 900 |
| 39X | Stanford | 2292.016000 | 21.985270 | 10/19/66–11/03/66 | 300 |
| 39Y | 11, 41, 42, 51, 61 | 2292.016000 | 21.988905 | 10/19/66–11/03/66 | 900 |
| 40X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 11/02/66–11/17/66 | 900 |
| 40X | Stanford | 2292.023000 | 21.985280 | 11/02/66–11/17/66 | 300 |
| 40Y | 12, 41, 42, 51, 61 | 2292.022000 | 21.988915 | 11/02/66–11/17/66 | 900 |
| 41X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 11/16/66–12/01/66 | 900 |
| 41X | Stanford | 2292.023000 | 21.985280 | 11/16/66–12/01/66 | 300 |
| 41Y | 12, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 11/16/66–12/01/66 | 900 |
| 62F | 14 | 2292.023000 | 21.985280 | 11/27/66–11/30/66 | 300 |
| 62G | 14 | 2292.023000 | 21.988935 | 11/27/66–11/30/66 | 300 |
| 42X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 11/30/66–12/15/66 | 900 |
| 42X | Stanford | 2292.023000 | 21.985280 | 11/30/66–12/15/66 | 300 |
| 42Y | 12, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 11/30/66–12/15/66 | 900 |
| 43X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 12/14/66–12/30/66 | 900 |

Table 45 (contd)

| Predict | Stations | Spacecraft RF frequency, MHz | Transmitter reference, MHz | Coverage | Sample rate, s |
|---|---|---|---|---|---|
| 43X | Stanford | 2292.023000 | 21.985280 | 12/14/66–12/30/66 | 300 |
| 43Y | 12, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 12/14/66–12/30/66 | 900 |
| 44X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 12/29/66– 1/14/67 | 900 |
| 44X | Stanford | 2292.023000 | 21.985280 | 12/29/66– 1/14/67 | 300 |
| 44Y | 12, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 12/29/66– 1/14/67 | 900 |
| 45X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 1/13/67– 1/29/67 | 900 |
| 45X | Stanford | 2292.023000 | 21.985280 | 1/13/67– 1/29/67 | 300 |
| 45Y | 12, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 1/13/67– 1/29/67 | 300 |
| 45V | 12, 14, 41, 42, 61, 62, 51 | 2292 023000 | 21.985280 | 1/16/67– 1/18/67 | 900 |
| 45W | 12, 14, 41, 42, 61, 62, 51 | 2292.023000 | 21.988940 | 1/16/67– 1/18/67 | 900 |
| 45C | 14, 41, 42, 61, 51 | 2292.022500 | 21.985285 | 1/20/67 (00.00–05:10) | 300 |
| 45C | 14, 41, 42, 61, 51 | 2292.022500 | 21.985285 | 1/20/67 (05:10–06:25) | 10 |
| 45C | 14, 41, 42, 61, 51 | 2292.022500 | 21.985285 | 1/20/67 (06:25–20.00) | 300 |
| 45D | 14, 41, 42, 61, 51 | 2292.022500 | 21.988935 | 1/20/67 (00:00–05:10) | 300 |
| 45D | 14, 41, 42, 61, 51 | 2292.022500 | 21.988935 | 1/20/67 (05:10–06:25) | 10 |
| 45D | 14, 41, 42, 61, 51 | 2292.022500 | 21.988935 | 1/20/67 (06·25–20:00) | 300 |
| 46X | 12, 41, 42, 51, 61 | 2292.023000 | 21.985280 | 1/28/67– 2/13/67 | 900 |
| 46X | Stanford | 2292.023000 | 21.985280 | 1/28/67– 2/13/67 | 300 |
| 46Y | 14, 41, 42, 51, 61 | 2292.023000 | 21.988935 | 1/28/67– 2/13/67 | 900 |
| 47X | 14, 41, 42, 51, 61 | 2292.022500 | 21.985280 | 1/20/67– 2/01/67 | 900 |
| 47Y | 14, 41, 42, 51, 61 | 2292.022500 | 21.988940 | 1/20/67– 2/01/67 | 900 |
| 48X | 14, 41, 42, 51, 61 | 2292.022500 | 21.985285 | 1/31/67– 2/15/67 | 900 |
| 48Y | 14, 41, 42, 51, 61 | 2292.022500 | 21.988945 | 1/31/67– 2/15/67 | 900 |
| 49X | 14, 41, 42, 51, 61 | 2292.022500 | 21.985285 | 2/12/67– 3/01/67 | 900 |
| 49Y | 14, 41, 42, 51, 61 | 2292.022500 | 21.988945 | 2/12/67– 3/01/67 | 900 |
| 49Z | Stanford | 2292.022500 | 21.985285 | 2/12/67– 3/01/67 | 300 |
| 50X | 14, 41, 42, 51, 61 | 2292.022600 | 21.985285 | 2/28/67– 3/16/67 | 900 |
| 50Y | 14, 41, 42, 51, 61 | 2292.022500 | 21.988945 | 2/28/67– 3/16/67 | 900 |
| 50Z | Stanford | 2292.022500 | 21.985285 | 2/28/67– 3/16/67 | 300 |
| 51X | 14, 41, 42, 51, 62 | 2292.022700 | 21.985285 | 3/15/67– 4/01/67 | 900 |
| 51Y | 14, 41, 42, 51, 62 | 2292.022700 | 21.988935 | 3/15/67– 4/01/67 | 900 |
| 51Z | Stanford | 2292.022700 | 21.985285 | 3/15/67– 4/01/67 | 300 |

*Summary.* The Deep Space Station performance for this report period was within tolerance of the specified commitments. The successful events that occurred during the report periods are as follows.

(1) January 20, 1967, lunar occultation, DSS 12, 0521:19 GMT.
January 20, 1967, lunar emergence, DSS 12, 0611:45 GMT.

(2) October 24, 1966, telemetry bit rate, 256 bits/s.
November 6, 1966, telemetry bit rate, 64 bits/s.
December 11, 1966, telemetry bit rate, 16 bits/s.
February 3, 1967, telemetry bit rate, 8 bits/s.

(3) January 3, 1967, channel 7 receiver connected to the high-gain antenna during a DSS 14 track.

(4) January 23-27, 1967, DSS 62 location determination from *Pioneer* tracking data.

(5) January 13, 1967, rubidium time standard, DSS 14.

(6) February 17, 1967, digital resolver in use at DSS 14 for *Pioneer* tracking data extended accuracy performance.

*Metric data summary.* The metric data summary is a log of all good metric data available for *Pioneer VII* in the interval of pass 46 to pass 191. The total number of equivalent 60-s good tracking points for this interval is 81, 575 data points.

*RF performance.* The Deep Space Station RF performance for passes 46 through 191 was within the Project's predicted signal strength (Table 41). All Deep Space Stations were at 10 kW as of pass 60 with the exception of DSS 14, which went to 10 kW on pass 153 (Fig. 72). On January 3, 1967, the Deep Space Stations connected channel 7 to the high-gain antenna (a calculated 10- to 11-dB gain). As a result, the average uplink power reading on the engineering printout was −128 dBmw, which is an 11-dB improvement from −139 dBmw on channel 6.

The downlink receiver signal strength is provided in Table 41, which contains the predicted signal strength, average signal strength, receiver bandwidth, and threshold. The predicted signal strength from the Project is shown for the purpose of comparison of Deep Space Station performances. As shown in the table, performance was at, above, and below predicted values. In most cases, the station was within 1 dBmw of predicted value. When the station is within 1 dBmW of predicted value, all stations can be interpreted to be at the same average value.

A problem at DSS 42 was noted in the AGC readings for pass 177 on day 40. The AGC reading fluctuated continuously from −162.5 to −164.5 dBmW every 9 s. The AGC fluctuation is under investigation.

On January 3, 1967, DSS 14 sent the command, enabled at DSS 12, to connect channel 7 to the high-gain antenna (a 10-dB gain) in order to address the spacecraft. The uplink power for channel 6 was nearing the calculated receiver threshold of approximately −146.7 dBmW. The reported reading for channel 7 receiver on the high-gain antenna is −130 dBmW. The calculated threshold for channel 7 is −147.7 dBmW. Also, Fig. 69 plots the transmitter power at 10 kW for the 85-ft antenna. The power for the 210-ft (DSS 14) antenna, however, is between 2 and 5 kW because of the increased power gain ratio of 8 dB.

In Figs. 70 and 71, the actual hours vs the scheduled RF hours tracked during that pass interval is shown (1985.02 vs 2032.32 h).

The percentage of hours tracked during passes 46 through 135 (December 31, 1966) is shown in Fig. 70 as 97%; Fig. 71 shows passes 136 through 191 as a total of 98% tracked. Also, in Figs. 70 and 71, the RF two-way in-lock percentages of 96 and 97% are shown. These percentages do not indicate the amount of data taken, since data is also taken in one-way and three-way tracking modes. Testing causes loss of two-way lock, not loss of *Pioneer* telemetry data.

Testing is required to determine the spacecraft best lock receiver frequencies. These frequencies are used in generating optimum predictions six weeks in advance for the Deep Space Stations. The best-lock analyses are covered in a separate report.

Most of the out-of-lock conditions are attributed to hardware failures. These failures and anomalies, which include transmitter and exciter repairs, power outages, and abnormal weather conditions, are under investigation.

*Telemetry performance.* The quantity of real-time telemetry data obtained indicates a coverage of 97.5% for the total time tracked. This coverage includes one-, two-, and three-way in-lock performance by the Deep Space Stations. Also, the real-time telemetry coverage

on the magnetic tape recorder (FR-1400) indicates 100% data recovery. In addition to the regular scheduled passes, there were four additional solar flare passes with real-time telemetry coverage.

The performance of the real-time telemetry is given by the bit error rate printout on the engineering telemetry data. The threshold bit error rate for 0.1% margin on the engineering telemetry data is 0.109 parity errors in 1000 frames. In actual operations, an acceptable error rate may be an order of one magnitude larger, depending upon the experimenter's requirements. The bit error rate listed in Table 42 indicates several abnormally high rates above 0.1%. These rates occurred during the middle of the passes. The high values at the beginning (2 h) and at the end (2 h) of the pass have been neglected. These high rates are attributed to atmospheric effects at low signal strengths. Some of the periods of high rate are under investigation. An example of this is the period when receiver AGC indicated a constant AGC reading or better than the predicted signal strength level. This problem occurred at two different stations on passes 143 and 146. On passes 177 through 191 at DSS 42, the intermittent high bit error rate can be attributed to the receiver dropouts and the cyclic receiver AGC reading as noted in the RF performance. A station system calibration method improved S/N ratio for a lower bit error rate performance.

Table 43 calculates the predicted telemetry bit rate mode change from 64 to 16 bits/s. The predictions are based on range in km $\times 10^6$. The predicted threshold for 16 bits/s was for January 30, 1967. However, the actual threshold was on February 3, 1967, which was within 0.3 dBmW. As can be seen, the predicted and actual signal strengths are very close. This is further explained by the fact that the station was at or above the predicted signal strength.

Figure 78 shows the actual *Pioneer VII* bit rate mode history vs range in km $\times 10^6$. *Pioneer VII* is presently at 8 bits/s as of day 173. As can be seen from the points plotted, an exponential growth can be approximated for the bit rate mode variations. The exponential trend is further presented in Figs. 72 and 73 for 16 and 8 bits/s, respectively. These figures show that as the signal strength nears threshold, the bit error rate rapidly increases. The maximum allowable bit error rate increase depends upon the experimenter's requirements.

From the computer listing, a record of the bit rate changes is presented in Table 43. As these tables show,

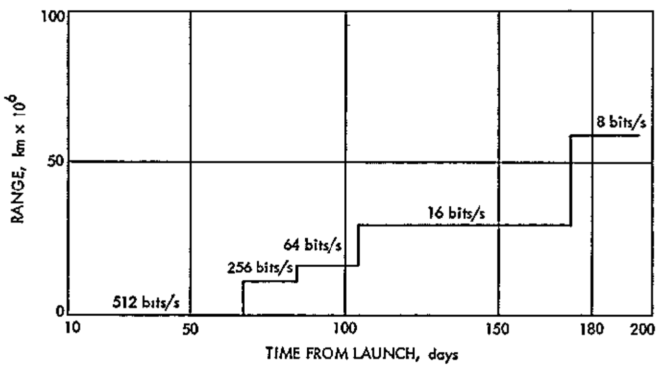


**Fig. 78. Range vs days after launch**

the highest telemetry bit rate mode was 256 bits/s on days 4 and 17. The high bit rate performance was provided by DSS 14. The 85-ft antenna maintained a 16-bits/s performance until day 33, February 3, 1967, when the prime telemetry readout mode was switched to 8 bits/s. Table 53 also presents the average bit error rate ($\overline{\text{BE}}$) and bit rate mode of the spacecraft.

The bit error rate is useful in determination of the station's telemetry performance and is a qualitative measure of the number of parity errors counted for that bit rate mode. In the case of 512, 256, and 64 bits/s, the interval is counted over 10 min; whereas, 16 and 8 bits/s are counted for 1 h.

Figure 74 presents the in-lock (two-way) percentage (96%) for the *Pioneer* GOE demodulator. The TCP has a higher percentage of performance for passes 46 through 191 and is shown separately. Likewise, the FR-1400 has performed at 100% without loss of *Pioneer* telemetry.

The GOE demodulator/TCP lock was computed for only two-way interrogation of the spacecraft. However, the demodulator/TCP locks when the station is in one-way and three-way tracking modes. Therefore, the above percentage (96%) doesn't include the one- and three-way lock conditions. If these tracking modes were added to the two-way lock percentages, a much higher percentage of data coverage could be realized.

The anomalies of the GOE occurred on passes 68 and 70 at DSS 12. The demodulator exhibited intermittent lock on 512 and 256 bits/s during these passes. Also, DSS 51, on passes 142 and 183, had demodulator failures that lost over 1 h of data. These anomalies are under investigation. No TCP failures have been reported during this report period. The TCP performance could be

considered excellent (99.9%), when theoretically removed from the demodulator and receiver performance.

No magnetic tape recorder outages were reported that caused loss of *Pioneer* telemetry data. Therefore, the performance of the FR-1400 could be considered greater than 99.9%.

*Command performance.* The command summary for the Deep Space Stations presents all commands transmitted within a precalculated command tolerance. All commands were transmitted, as directed by the Project, with several command problems occurring during this reporting period. On passes 141 and 142, DSS 42 was reinstalling the *Pioneer* GOE and was not able to send commands to the spacecraft.

Figures 75 and 76 show the command summary for the Deep Space Stations during passes 46 through 191. In the case of non-GOE stations such as DSS 11 and DSS 14, the commands are placed into the encoder at DSS 12 for transmittal. At the time of transmittal, these commands are enabled at DSS 12 and are sent via the microwave link to DSS 11 or DSS14. The commands are verified by the computer at DSS 12 when sent and executed on the spacecraft. Table 44 indicates individual commands transmitted by the station for passes 46 through 191. Station 41 did have microwave capability to a GOE station and therefore could not send *Pioneer* commands.

The command anomalies (which have since been investigated and resolved) were as follows:

| *Pass* | *Station* | *Remarks* |
|---|---|---|
| 48 | 12 | Command 34 not checked |
| 58 | 12 | Commands 62, 53 entered early |
| 78 | 12 | Command tolerance |
| 99 | 51 | Command tolerance |
| 112 | 51 | Command tolerance |
| 170 | 11/12 | Command 71 late by 10 s |
| 184 | 51 | Command 51 tolerance |

*Predict outputs.* This section consists of all predictions generated between August 20, 1966, and April 1, 1967, for *Pioneer VII*. Table 45 presents the predict number, the stations for which the predicts were generated, the spacecraft auxiliary oscillator or driver frequency, the ground transmitter synthesizer frequency for best lock at zero doppler, dates for which predicts are effective, and the sample rate, which is the interval between predict printouts.

The predict number normally consists of two parts. The first part is a two-digit number that indicates the predict run; the second part is an alphabetic letter that indicates the channel for which the predicts are generated. The first (alphabetically) of two letters is for channel 6 and the second for channel 7. An example of this would be predict set 45X for channel 6 and 45Y for channel 7.

Predict sets 45V and 45W were special predicts used for finding a more accurate station location for Station 62. Predict sets 45C and 45D were also special predicts because of a moon occultation of *Pioneer VII* spacecraft on January 20, 1967. A sample rate of 10 s was used for 75 min during occultation.

Predicts for Stanford are generated every 300 s (5 min) instead of every 15 min as for the Deep Space Stations. This requires a disproportionate amount of time to be spent on Stanford predicts. An effort is being made to supply Stanford predictions on magnetic tape for long intervals, and this should help equalize the workload.

*Predicted frequency performance.* Figures 79 and 80 are plots of the rest frequency measurements since launch for channels 6 and 7. Predicted curves for rest frequency are overplotted in order to give an idea of

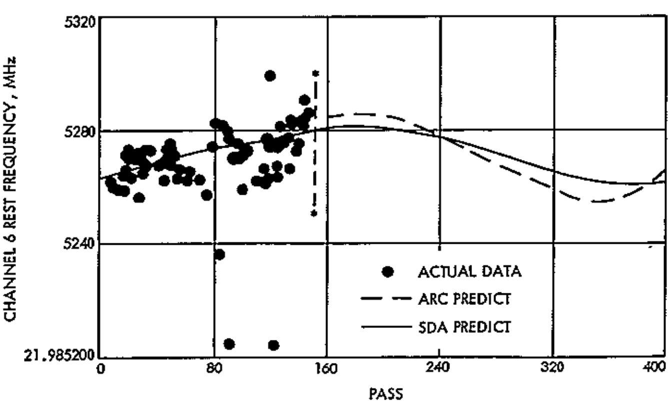


**Fig. 79. Channel 6 rest frequency**

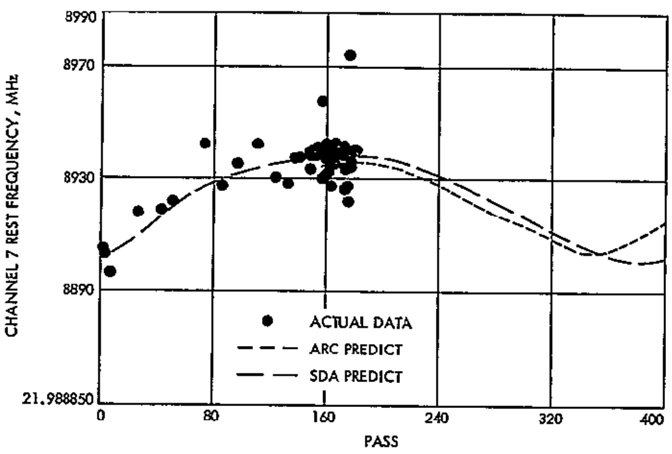


**Fig. 80. Channel 7 rest frequency**

the accuracy of the predictions. The differences between ARC and SDA predictions are relatively minor, except that ARC predictions do not reflect the actual perihelion of pass 373.5. ARC predictions show perihelion to be near pass 350.

The frequency data available for channel 6 makes the central tendency of the frequency curve somewhat a matter of conjecture. Future data will probably not be available to confirm this, but since tracking will be primarily on channel 7 this should not be a problem.

Figure 77 is a plot of measured driver frequency. This data is presented with ARC predicted values which do not fit the data well. The ARC predictions are based on prelaunch data, which is not adequate for accurate prediction.

The scarcity of points in Fig. 77 is indicative of how seldom one-way tracking data is taken. A procedure is being instituted whereby an estimate of driver frequency is made each track. This will give a much more complete history of driver frequency.

## Glossary

| | |
|---|---|
| AFETR | Air Force Eastern Test Range |
| AOS | acquisition of signal |
| APS | antenna pointing subsystem |
| ARC | Ames Research Center |
| BIH | built-in hold |
| CMD | command |
| DIS | digital instrumentation subsystem |
| DOB | data operations branch |
| DPS | data processing station |
| DSIF | Deep Space Instrumentation Facility |
| DSN | Deep Space Network |
| DSS | Deep Space Station |
| FA | auxiliary oscillator frequency |
| FB | best-lock frequency |
| FPAA | flight path analysis area |
| FPAC | flight path analysis and command |
| FSM | frequency shift modulation |
| FTS | frequency and timing subsystem |
| GCF | Ground Communications Facility |
| GOE | ground operational equipment |
| GSFC | Goddard Space Flight Center |
| HSD | high-speed data |
| K1 | receiver reference frequency |
| LOS | loss of signal |
| MECO | main engine cutoff |
| MOPS | matrix operations programming system |
| MSFN | Manned Space Flight Network |
| NASCOM | NASA Communications System |
| OCC | operations control chief |
| OD | orbit determination |
| ODC | operational document control |
| OVCS | operational voice communications system |

## Glossary (contd)

| | |
|---|---|
| RIS | range instrumentation ship |
| RTCC | real time computing center |
| RTCF | Real Time Computing Facility |
| SCAMA | switching, communications and monitoring arrangement |
| SCM | S-band Cassegrain monopulse |
| SDA | systems data analysis |
| SECO | sustainer engine cutoff |
| SFOF | Space Flight Operations Facility |
| SRO | supervisor of range operations |
| SPAC | spacecraft performance analysis and command |
| SPE | static phase error |
| SSAC | space science analysis and command |
| TCP | telemetry command processor |
| T–D | transmitter–distributor |
| TDA | tracking and data acquisition |
| TDH | tracking data handling |
| TDM | time division multiplex |
| TDS | Tracking and Data System |
| TPS | telemetry processing station |
| TXR | transmitter subsystem |
| UCSS | unified communications subsystem |
| XA | ground transmitter VCO frequency setting |

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